Operations Research and Analysis

Preliminary Report 12a:

# A Simplified Approach to Baselining Delays and Delay Costs for the National Airspace System (NAS)

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**ABSTRACT**

This report describes a methodology and summarizes the results for estimating the total delay and weather delay in the National Airspace System (NAS). It evaluates NAS delays from one year of 1996 data and presents a logical framework for baselining the cost of delay (per the scheduled block times as they adhere to the Official Airline Guide (OAG) schedule) for a given year. Delay costs from 1996 operations are estimated to be approximately \$3B; \$1.2B in operating costs to the airlines and \$1.8B to the passengers. Although the delays that are evaluated in this report are based on 1996 operations, the delay costs will not be substantially different in 1997 or 1998; it is the framework applied in this analysis that is of predominant importance.

The delays and cost of delays annotated in this report do not capture the airlines' necessity to establish block times that will ensure consistently high rates of "on-time performance"; i.e., any flight time reduction within the current and future constrained ATC system can save the airlines significant direct operating costs. Additional analysis that is required to expand this work includes: gathering better insights into the magnitude of avoidable and unavoidable weather delays, defining and quantifying "optimal flight times", measuring impacts of lower block times, and identifying measures of effectiveness for capturing interrelationships of NAS operations. As ASD-400 continues to maintain responsibility, which includes tracking benefits, for conducting Investment Analyses of major FAA acquisitions, , it is critical that current program baselines and planned NAS initiatives are better understood and measured.

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## 1.0 BACKGROUND

Historically, the FAA has spent billions of dollars modernizing the NAS through the development, acquisition, and implementation of new technologies. Many of these capabilities entrenched in the FAA programs have made claims that delays will be reduced significantly as air traffic demand grows. The bulk of the claimed estimated user benefits are in the delay savings. The 1997 Capital Investment Plan (CIP) stated that the to-go benefits (constant $96B) of CIP programs, which include programs predicted to provide large delay savings such as the Center TRACON Automation System (CTAS), Integrated Terminal Weather System (ITWS), and the Wide Area Augmentation System (WAAS) are estimated to be $128B through 2015. Delay savings and increased flight efficiency are estimated to comprise approximately 68% or $75B through these out-years.

There are major FAA-funded programs that are expecting delay savings; however, very few programs have been adequately tracked or sufficiently proven to confirm their previous projected delay savings. Furthermore, procedural changes, airspace resectorizations, and airport improvements from the Airport Improvement Plan (AIP), does not rely on the planned future acquisitions, have certainly had a role in controlling delay growth. Yet, it continues to be extremely difficult to discriminate the savings due to acquisitions and savings from procedural changes.

The intent of this document is to identify and apply a methodology for estimating the potential annual total delay and associated delay costs in the National Airspace System (NAS). At the same time, a rough estimate of the cost of weather delays is presented while recognizing that a substantial proportion of this delay is unavoidable regardless of what improvements through acquisitions, runway improvements or procedural improvements are made. Note: a very important distinction is that this report identifies delays as deviations from the schedule since it is a given that constraints and inefficiencies in the ATC system will always exist. The report briefly looks at a quick method (see Section 5.3) for capturing the potential dollar impact of reduced scheduled block times.

The first version of the preliminary report (completed in August 1998) solicited many comments from both FAA and industry. Many constructive and useful comments were received; this report addresses and attempts to incorporate some of the key concerns, suggestions, and recommendations whenever possible. Moreover, subsequent to the distribution of the draft report, ASD-400 hosted a delay workshop in November 1998 that attempted to gather input and feedback from the FAA, industry, and academia. ASD-400 took an action item to follow up on some of the group's recommendations and extend the analysis to assess inefficiencies in the NAS that could reduce the potential delay costs, i.e., within the constraints of an ATC system that continues to deliver more passengers each year. This effort is exploring different ways of measuring “optimal flight times”.

## 2.0 INTRODUCTION

This paper discusses the methodology and summarizes the results for estimating the total delay and weather delay in the NAS. The work was developed in response to several ongoing initiatives. These include:

- A General Accounting Office (GAO) inquiry (March 1998) to Investment Analysis and Operations Research (ASD-400), about the cost of weather delays in support of their evaluation of NAS weather programs.

- Work that ASD-400 needs to baseline in support of the investment analysis process so that individual programs, selected NAS initiatives such as Free Flight Phase 1 (FFP-1), weather programs, and NAS modernization programs that purport to reducing delays are measured and evaluated against a realistic level.

- General support to other initiatives such as Research and Acquisition (ARA) Goal #8, *develop and demonstrate the capability of new systems to decrease weather delay 10% by 2002* and the interagency Joint Action Group for Aviation Weather (JAG/AW).

- Validation of previous FAA reports that indicated up to $10B annual NAS delay; $4B annual weather related delay; and $110B in weather delay costs from 2001-2021 at the 45 Integrated Terminal Weather System (ITWS) airports. [1]

This paper highlights the derivation of baseline 1996 total delays and weather delays. It discusses how Airline Direct Operating Costs (ADOC) and Passenger Value of Time (PVT) costs are applied in the analysis. Furthermore, it suggests a vehicle for projecting future NAS delays and delay costs.

The report is divided into four sections: 1) an evaluation of the total delay, 2) the conversion of total delay into weather delay, 3) discussion of the results and future delay projections, and 4) the next steps required to extend the analysis to other years.

## 3.0 TOTAL DELAY

### 3.1 Data Sources

There were several key databases and sources that were used in computing delays, both arrival and gate-to-gate delays. The study team used the following sources to develop the results:

- Airline Service Quality Performance (ASQP)[2] – DOT's reporting system that tracks air carrier domestic flight information of 10 commercial carriers. These carriers account for more than 90% of domestic operating revenues.

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[1] Cost-benefit analysis of ITWS, March/April 1995, Section 7-1, pg. 23.

[2] The 10 reporting carriers in the baseline year 1996 are: Alaska Airlines, America West, Continental Airlines, Delta Airlines, Northwest Airlines, Southwest Airlines, Trans World Airlines, United Airlines, and US Air.

- Official Airline Guide (OAG) - provides the scheduled arrival and departures times for scheduled air carrier and commuter flights.

- Terminal Area Forecasts (TAF) Fiscal Years 1997-2010, FAA-APO-97-7, October 1997 – provides the actual number and projected number of operations identified by air carrier, air taxi/commuter, general aviation (GA), and military. All domestic and international flights to/from the U.S. are reflected in the values. It also provides enplanements for air carrier and air taxi/commuter flights.

- FAA APO Publication 97-1, June 1997 – Treatment of Values of Passenger Time in Economic Analysis.

- Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs, June 1998. Includes the Department of Transportation's (DOT) Form 41 Financial Data. This source provides ADOC by block hour. The values are reported by air carrier and type of aircraft.

- Input from the Operational Data Reporting Requirements Network (OPSNET), M.I.T Lincoln Laboratories, Air Transport Association (ATA), and National Climatic Data Center (NCDC) historical hourly surface observation weather data.

## 3.2 Delay Definitions

The analysis used the ASQP data to measure the delays. The arrival delays from the ASQP data reflect downstream effects (delay propagation) of multiple flight legs for a particular aircraft's daily itinerary. OPSNET, the official delay reporting system for the FAA, which is often very useful for addressing certain types of questions, is not appropriate for computing annual delays and delay costs. OPSNET's reported delays of 15 minutes or more does not provide a reflection of the total delay minutes that need to be evaluated (i.e., delays less than 15 minutes). Any Air Traffic Control (ATC) induced delays (departure, arrival, and en route caused by bad weather, equipment outages, terminal congestion, or runway limitations) that are reported in OPSNET are reflected in the variability of the actual ASQP gate-to-gate times. Furthermore, the PVT reflects the actual arrival time beyond the scheduled arrival time; in OPSNET it is virtually impossible to derive the PVT based on its definition of arrival delay.

### 3.2.1 ASQP Delay

Two types of delays from the ASQP were applied in the analysis. Note: flight efficiency using the airborne time from wheels-off to wheels-on was not evaluated, i.e., regardless of whether or not a city pair has a wide range of flight times, it was assumed that there were no delays as long as the flight arrived within its schedule.

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Approximately 35 smaller carriers offer domestic scheduled passenger service that are not required to report to DOT.

a) **Arrival delay** - the difference between the OAG scheduled gate arrival time and actual gate arrival time.

b) **Gate-to-gate delay (flight delay)** - the difference in the scheduled gate-to-gate and actual gate-to-gate times. The scheduled gate-to-gate time was computed by subtracting the scheduled gate departure time from the scheduled gate arrival time. The actual gate-to-gate time was computed by subtracting the actual gate departure time from the actual gate arrival time.

*The analysts recognize that block times have been increasing slightly for many city pair flights over the years. However, the constraints of the ATC system that force airlines' to build block times to maintain operational integrity will remain, especially for a NAS that has been and will continue to deliver increased throughput.*

A potential gain in flight efficiency has been estimated by the Logistics Management Institute (LMI) in work that supported the CNS/ATM Focused Team (C/AFT) efforts in 1998. Based on published OAG data for April 1993 through April 1997, LMI found that scheduled block times for flights among the 29 hub airports in the NAS increased by 1.5 minutes.[3] Of these 29 airports, 15 airports showed schedule time increases of one minute or more; conversely, seven of these hub airports showed slight reductions in scheduled block times during this 4-year period. Another study by the DOT Office of Inspector General reported that in a 10-year period (1988-1997) scheduled gate-to-gate times have increased by almost 3 minutes. 73% of the 2,000+ routes studied had increased gate-to-gate times.[4] The number of air carrier operations in this 10-year period increased by 15%.

### 3.2.2 OPSNET Delay

The OPSNET delays were not used in developing the minutes of delays; however, the information by cause of delay was applied to one of the methods used to compute the amount of weather delay. This methodology is discussed in Section 4.1. Reportable delays of 15 minutes or more were provided by ATO-200, Air Traffic Operations and Tactical Operations using OPSNET. The definitions in OPSNET per Order 7210.55A, Operational Data Reporting Requirements, 2/6/98, are as follows:

a) **Departure delay** – when the taxi time (pushback from the gate to wheels-off time) exceeds a specific airport's average taxi time by 15 minutes or more.

b) **Arrival delay** – when the flight's average airborne holding time exceeds 15 minutes, i.e., the time an aircraft enters a holding pattern until the time when ATC terminates the hold. This hold is in the "last tier" (Center containing the destination airport).

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[3] Airline Metric Concepts for Evaluating Air Traffic Service Performance, Report of the Air Traffic Services Performance Focus Group CNS/ATM Focused Team, February 1, 1999, pg. 6.

[4] Office of Inspector General Audit Report, Air Carrier Departure Data, Department of Transportation, CE-1999-054, February 5, 1999, pg. 8.

c) **En route delay** – same as OPSNET arrival delay, except the restriction occurs in any tier except the last tier, i.e., Air Route Traffic Control Center (ARTCC) or Terminal Radar Approach Control (TRACON) facility.

### 3.3 Assumptions

There were several assumptions made in the analysis. They are categorized by time, cost, and demand. Some were generalizations; however, given the time to conduct the study and the intent of the analysis, they appear to be reasonable. The main objective of the analysis is to baseline annual delay by doing a data-driven bottoms-up analysis. The following are the key assumptions for this analysis:

Time Assumptions

- Both arrival and flight delays in excess of 120 minutes were not considered. The air carrier (AC) flights from the ASQP delayed more than 120 minutes account for approximately 1% of the total arrival delay time and 0.5% of the frequency of total delays.

- Non-ASQP air carrier and air taxi/commuter flights (AT), which include scheduled commuters and regional carriers, have the same delay distribution as the ASQP carriers.[5]

- The numbers of delays for non-ASQP and air taxi/commuter flights are proportional to the ASQP air carrier delays (see Appendix A)

- Delay distributions were derived from one full year of 1996 ASQP data. There is no stratification for types of events such as convective weather, e.g., thunderstorms, equipment failures, and power outages. These types of delays are reflected in the numbers.

- The OAG scheduled departure and arrival times were not updated for NAS flight plan messages or other messages to account for a carrier's schedule updates.

- GA delays are not computed in this analysis; they are extrapolated, then estimated.[6]

Cost Assumptions

[5] ASD-400/SETA examined nine months of 1998 CODAS data. The analysis showed that there is no statistical significant difference in the distributions. See Appendix A for a detailed discussion.

[6] Preliminary analysis indicates that the cost of GA delays is less than 5% of the total air carrier and air taxi/commuter costs even when assuming that all GA aircraft operate on a schedule. Given that the majority of the GA aircraft are not scheduled driven and thus "delays" are very difficult to measure, it was decided to ignore the GA delay costs for this analysis.

- The PVT is based on the FAA APO-97-1 Publication Treatment of Values of Passenger Time in Economic Analysis.

- The ADOC is based on DOT's Form 41 and T-100 reports. The costs, which are derived from the Economic Values for Evaluation of FAA Investment and Regulatory Programs, FAA-APO-98-8, June 1998, are weighted by air carrier and fleet mix for a representative weekday in the NAS. Crew, maintenance, and fuel & oil costs are included in the cost. Depreciation is not included.

- The ADOC delay costs were based on the average derived block-to-block ADOC; no adjustment was made for lower ground versus higher airborne costs.

Demand Assumptions

- Cancellations and diversions are not considered.

- The TAF (1997-2010) was used to baseline air carrier, air taxi/commuter, and GA airport's operations and enplanements from actual reported 1996 values. 433 towered airports (315 FAA and 128 Federal contract towers) are included in the extrapolation.

- An adjustment factor of approximately 60% reflected the system average of the passengers getting off the aircraft after one leg for all commercial and air taxi/commuter flights.

- The number of passengers per aircraft is computed for each airport in the ASQP. It is the ratio of total departures to enplanements by air carrier, air taxi/commuter,[7] and GA flights.

### 3.4 Methodology

Figure 1 represents the process used in this analysis for computing the delays from the ASQP. Note: all scheduled departure and arrival times are carried over to the ASQP from the OAG.

[7] Air carrier operations represent either a takeoff or landing of a commercial aircraft with seating capacity of more than 60 seats; air taxi or commuter operations have 60 or fewer seats.

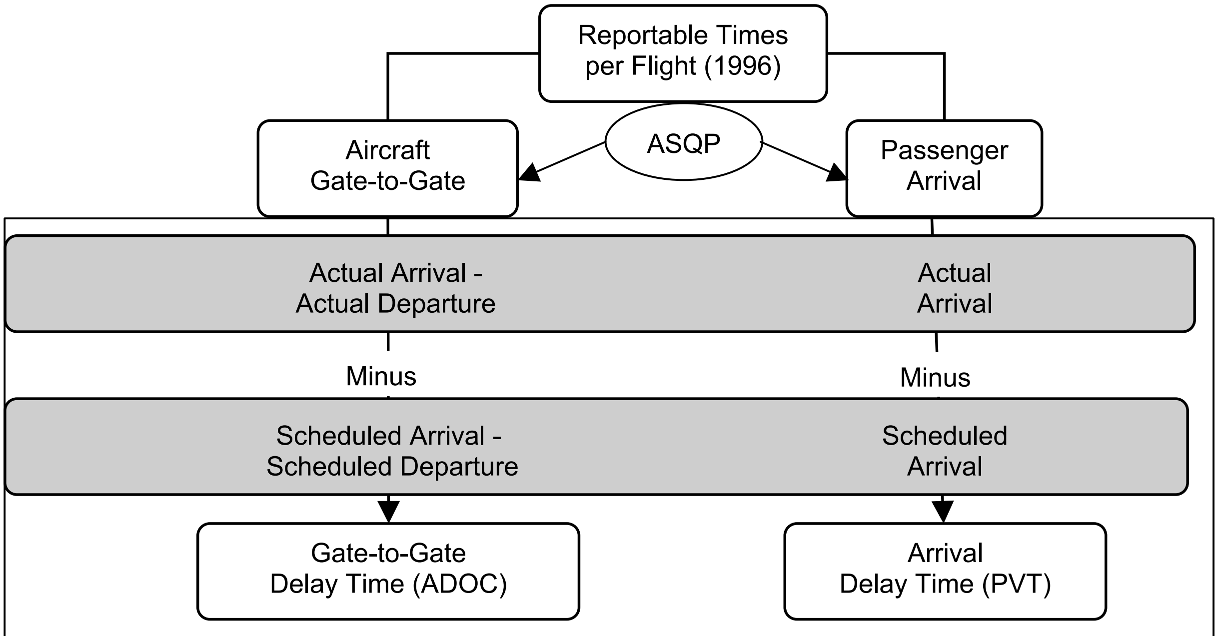


**Figure 1. Delay Computation Methodology**

Table 1 illustrates the four possible cases of flights from Atlanta (ATL) to Charlotte (CLT) that occurred during the analysis year 1996. The impact on the applicable delay is denoted after each case. The identical cases exist for all city pairs in the ASQP.

| Case | Flight | Date | Dep | Arr | Actual Dep Time | Actual Arr Time | OAG Dep | OAG Arr | OAG_ G2G | Act_ G2G | G2G Del | Arr_ Del |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2022 | 960601 | ATL | CLT | 0619 | 0710 | 0623 | 0715 | 52 | 51 | 0 | 0 |
| 2 | 588 | 960601 | ATL | CLT | 1008 | 1100 | 1000 | 1055 | 55 | 52 | 0 | 5 |
| 3 | 2054 | 960604 | ATL | CLT | 2121 | 2231 | 2115 | 2217 | 62 | 70 | 8 | 14 |
| 4 | 323 | 960605 | ATL | CLT | 1152 | 1250 | 1155 | 1250 | 55 | 58 | 3 | 0 |

**Table 1. Sample of Delays (ATL to CLT)**

**Case 1:** Flight 2022 arrives 1 minute before the scheduled gate-to-gate time (51 minutes versus 52 minutes), and 5 minutes before the scheduled arrival time (7:10 a.m. versus 7:15 a.m.), result: no arrival or gate-to-gate delays

**Case 2:** Flight 588 arrives 5 minutes behind schedule (11:00 a.m. versus 10:55 a.m.); however, the gate-to-gate time is 3 minutes within the scheduled time (52 minutes versus 55 minutes), result: 5 minute arrival delay impacts PVT with no gate-to-gate delay

**Case 3:** Flight 2054 arrives 14 minutes behind schedule (22:31 p.m. versus 22:17 p.m.) with an 8-minute gate-to-gate delay (70 minutes versus 62 minutes), result: two types of delays, an 8-minute gate-to-gate delay and a 14-minute arrival delay that impact both ADOC and PVT

**Case 4:** Flight 323 experiences a 3 minute gate-to-gate delay (58 minutes versus 55 minutes) but still arrived on schedule at 12:50 p.m., result: no arrival delay, but a 3-minute gate-to-gate delay that impacts ADOC

Each of the 175 airports (see Appendix B) was represented by at least one carrier from the ASQP. The total delay time (TD) (applies to both gate-to-gate and arrival delay) of each airport was computed by multiplying the number of delays ($n_l$) of length (l), (1-120) minutes as denoted by Equation 1.

$$1)\ TD = \sum_{i=1}^{i=120} n_l \bullet l$$

### 3.5 Extrapolation to the NAS

Extrapolations were necessary to account for the non-ASQP air carrier and air taxi/commuter flights. These flights were assumed to have delays proportional to their level of operations while operating during the same hours as the ASQP flights. Of course there are cases when this relationship is not true, but in the aggregate the results due to this assumption will not vary significantly.

Table 2 illustrates the delays for the 25 most frequently delayed airports derived from the ASQP. The ASQP/Total Air Carrier ratio for these airports ranges from a low of 39% at MIA, and airports with a high rate of international flights to a high of 93% at CLT. These airports account for 71% of the total gate-to-gate delay and 65% of the total arrival delay from the 175 airports.

| Delay Rank | Airport | ASQP G2G TOT Delay (Min) | ASQP Arrival Delay (Min) | CUM G2G Delay | CUM Arrival Delay | Ratio ASQP/Tot Carrier | Ratio AT/AC | PAX/AC | PAX/AT |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ORD | 1,340,529 | 2,919,810 | 7.0% | 5.8% | 0.75 | 0.16 | 73 | 25 |
| 2 | ATL | 1,272,074 | 2,602,068 | 13.7% | 11.0% | 0.79 | 0.26 | 87 | 13 |
| 3 | DFW | 1,110,511 | 2,163,691 | 19.5% | 15.3% | 0.78 | 0.37 | 74 | 19 |
| 4 | LAX | 755,311 | 2,151,182 | 23.4% | 19.6% | 0.68 | 0.48 | 83 | 10 |
| 5 | STL | 763,020 | 1,853,019 | 27.4% | 23.3% | 0.92 | 0.32 | 71 | 12 |
| 6 | SFO | 662,693 | 1,825,464 | 30.9% | 27.0% | 0.77 | 0.24 | 90 | 15 |
| 7 | EWR | 721,451 | 1,449,928 | 34.7% | 29.8% | 0.66 | 0.36 | 71 | 19 |
| 8 | PHX | 550,051 | 1,575,878 | 37.5% | 33.0% | 0.88 | 0.25 | 79 | 6 |
| 9 | DTW | 542,423 | 1,189,231 | 40.4% | 35.4% | 0.83 | 0.29 | 74 | 14 |
| 10 | MSP | 555,899 | 1,129,905 | 43.3% | 37.6% | 0.86 | 0.40 | 79 | 10 |
| 11 | LAS | 355,300 | 1,164,801 | 45.2% | 39.9% | 0.80 | 0.28 | 99 | 7 |
| 12 | DEN | 355,183 | 1,107,228 | 47.0% | 42.1% | 0.80 | 0.34 | 90 | 10 |
| 13 | CLT | 400,919 | 1,040,779 | 49.1% | 44.2% | 0.93 | 0.46 | 68 | 12 |
| 14 | PIT | 400,243 | 1,034,534 | 51.2% | 46.3% | 0.91 | 0.59 | 64 | 11 |
| 15 | BOS | 426,261 | 994,400 | 53.4% | 48.3% | 0.74 | 0.88 | 85 | 10 |
| 16 | SEA | 359,108 | 1,028,388 | 55.3% | 50.3% | 0.66 | 0.63 | 87 | 13 |
| 17 | SLC | 385,534 | 966,728 | 57.3% | 52.2% | 0.85 | 0.46 | 87 | 12 |
| 18 | LGA | 399,935 | 925,181 | 59.4% | 54.1% | 0.76 | 0.34 | 75 | 12 |
| 19 | IAH | 431,654 | 880,450 | 61.7% | 55.8% | 0.77 | 0.26 | 68 | 18 |
| 20 | PHL | 337,762 | 903,958 | 63.4% | 57.7% | 0.80 | 0.63 | 69 | 11 |
| 21 | CVG | 372,629 | 739,340 | 65.4% | 59.1% | 0.81 | 1.03 | 69 | 17 |
| 22 | DCA | 293,457 | 730,524 | 66.9% | 60.6% | 0.87 | 0.45 | 75 | 14 |
| 23 | MIA | 306,334 | 678,414 | 68.5% | 61.9% | 0.39 | 0.51 | 49 | 17 |
| 24 | MCO | 263,359 | 720,064 | 69.9% | 63.4% | 0.66 | 0.58 | 100 | 11 |
| 25 | SAN | 184,114 | 680,997 | 70.9% | 64.7% | 0.83 | 0.41 | 91 | 10 |

**Table 2. 25 Most Delayed Airports (ASQP Flights)**

### 3.5.1 Delays

To estimate the total minutes of delay at each of the airports, the ratio of flights from the *ASQP air carriers* to the total number of air carrier flights per the TAF was calculated ($ratio_{ASQP/Total}$). For example, in 1996 there were 563,544 ASQP flights arriving at Chicago O'Hare (ORD) airport. The TAF gives the annual ORD air carrier operations (this implies that one-half of the operations are arrivals and one-half of the operations are departures) as 751,067. Therefore, the inverse of the ratio of .75 (751,067/563,544) was applied to give 1,786,599 total minutes of annual air carrier gate-to-gate delay from 1,340,529 minutes of annual ASQP gate-to-gate delay and 3,891,396 total minutes of annual air carrier arrival delay from 2,919,810 minutes of annual ASQP arrival delay. The amount of air taxi/commuter delays was determined in the same manner. Note: several comments were received that questioned this assumption. Further analysis evaluated nine months of 1998 CODAS data. It was decided that the difference was negligible and not worth adjusting in this analysis. See Appendix A for a detailed discussion.

*Air carrier gate-to-gate delay for ORD: 1/.75*1,340,529 minutes = 1,786,599 minutes*

*Air carrier arrival delay for ORD: 1/.75*2,919,810 minutes = 3,891,396 minutes*

### 3.5.2 ADOC and PVT Costs

In order to calculate ADOC and PVT costs for the NAS, the delays at each airport were summed to obtain total annual delays (see Table 5). The sum of each airport's enplanements (ENP), i.e., the number of passengers on the aircraft per the TAF, for both air carrier and air taxi/commuter was divided by the sum of the air carrier and air taxi/commuter operations (OPS) at its respective airport to obtain an average passenger load for each air carrier and air taxi/commuter operation. See the last two rightmost columns in Table 2. Equations 2 and 3 denote the ADOC and PVT cost extrapolations:

$$2)\ ADOC_{NAS} = (OPS_{NAS} / OPS_{175}) \cdot ADOC_{175}$$

The ratio of the NAS total operations to the total operations at these 175 airports was multiplied by the total ADOC.

$$3)\ PVT_{NAS} = (ENP_{NAS} \cdot OPS_{NAS}) / (ENP_{175} \cdot OPS_{175}) \cdot PVT_{175}$$

The ratio of NAS total enplanements and operations to 175 airports was multiplied by the PVT at each airport to get an estimate of the PVT costs. The average passenger load per flight was used to determine the minutes of passenger delay that resulted from each minute of arrival delay.

The results of the two cases for ADOC, PVT, for both the 175 airports and the extrapolation to the towered airports, are shown in Appendix C.

### 3.6 Airport Direct Operating Costs (ADOC)

The ADOC provides an estimate by aircraft category of the operating costs.[8] The average domestic dollars by block hour for each category type was applied in the analysis. Depreciation costs are not included in ADOC. The ADOC costs, which are comprised of fuel & oil, maintenance, and crew are as follows:

- Air carriers - $1,953 per block hour
- Air taxi - $702 per block hour
- General commuter aviation - $112 per block hour

The air carriers include both narrow body jets such as the B737-300 with an average operating cost of $1,926 per hour and wide body jets such as the B747-100 with an average operating cost of over $7,000 per hour. A fleet mix distribution of a representative day in the NAS (Thursday, March 12, 1998) from the ETMS, which contains all filed flight plans, was applied to develop the weighted ADOC costs of $1,953 per block hour for air carriers and $702 per block hour for air taxi/commuters. Out of 44,772 flights with either an air carrier or air taxi designation code, 74% are air carriers, 26% are air taxi/commuters. Table 3 summarizes the top 10 aircraft types for both air carrier and air taxi/commuter categories.

| AIR CARRIER | | | | | | AIR TAXI/COMMUTER | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A/C Type | % of Total AC Ops | Crew/Hr | Fuel/Hr | Maint/Hr | Total Var/Hr | A/C Type | % of Total AT Ops | Crew/Hr | Fuel/Hr | Maint/Hr | Total Var/Hr |
| B-737-300 | 12.0% | $817 | $598 | $511 | $1,926 | E120 | 13.6% | $205 | $270 | $344 | $819 |
| DC-9-30 | 6.8% | $772 | $673 | $625 | $2,070 | B190 | 7.8% | $225 | $240 | $306 | $771 |
| B-727-100 | 6.2% | $1,188 | $1,025 | $712 | $2,925 | BE20 | 6.8% | $193 | $265 | $298 | $756 |
| MD-80 | 6.0% | $934 | $700 | $475 | $2,109 | C550 | 3.7% | $225 | $312 | $338 | $875 |
| B-757 | 5.0% | $1,232 | $779 | $487 | $2,498 | C172 | 3.2% | $72 | $16 | $27 | $115 |
| B-737-100/200 | 4.4% | $855 | $650 | $665 | $2,170 | B190 | 3.0% | $225 | $240 | $306 | $771 |
| BE02 | 3.1% | $928 | $665 | $515 | $2,108 | BE90 | 2.8% | $205 | $270 | $344 | $819 |
| SF-340 | 3.0% | $257 | $140 | $283 | $680 | C560 | 2.7% | $225 | $339 | $375 | $939 |
| DHC8 | 2.8% | $928 | $665 | $515 | $2,108 | C310 | 2.2% | $72 | $62 | $83 | $217 |
| A-320 | 2.3% | $994 | $613 | $392 | $1,999 | C650 | 2.2% | $280 | $414 | $479 | $1,173 |

**Table 3. Top 10 Aircraft Types: Air Carriers and Air Taxi/Commuters**

The air taxi/commuter class includes both regional turboprops and small to mid-size corporate jets that have less than 60 seats. Other air taxi/commuters not denoted in the above table include the ATR-42 with an average of 46 seats per flight costs $952 per block hour and the Jetstream-31 with 19 seats costs $425 per block hour. Several smaller turboprops relative to the larger turboprops such as the ATR-42 and Jetstream-31 reduce costs even more.

[8] The values updated and derived from the "Economic Values for Evaluation of FAA Investment and Regulatory Programs," June 1998.

Figure 2 illustrates how adjustments can be made to account for the wide range in airline's reporting to DOT via Form 41 and T-100 reports. Each line represents air taxi/commuter costs increasing in 2% increments from 0% to 100%. The vertical axis is the percent change in gate-to-gate delay costs when both air carrier and/or air taxi/commuter ADOC change over those reported above. The horizontal axis represents the change in the air carrier ADOC, i.e., $1,953 for air carriers.

This figure can be interpreted as follows. A change in ADOC of 30% without a change in the air taxi/commuter costs (denoted by AT in the legend) will increase the total ADOC delay costs by approximately 24% (see Point A). Air taxi/commuter ADOC costs increasing by 20% (from $702 per block hour to $842 per block hour) while the air carrier ADOC costs increase by 10%, (see Point B) ($1,953 per block hour to $2,148 per block hour) give an increase in total ADOC delay costs of approximately 11%. Conversely, if the air taxi/commuter ADOC increases 60% without a change to the air carrier's ADOC, then the change in the total ADOC delay costs is approximately 10% (see Point C).

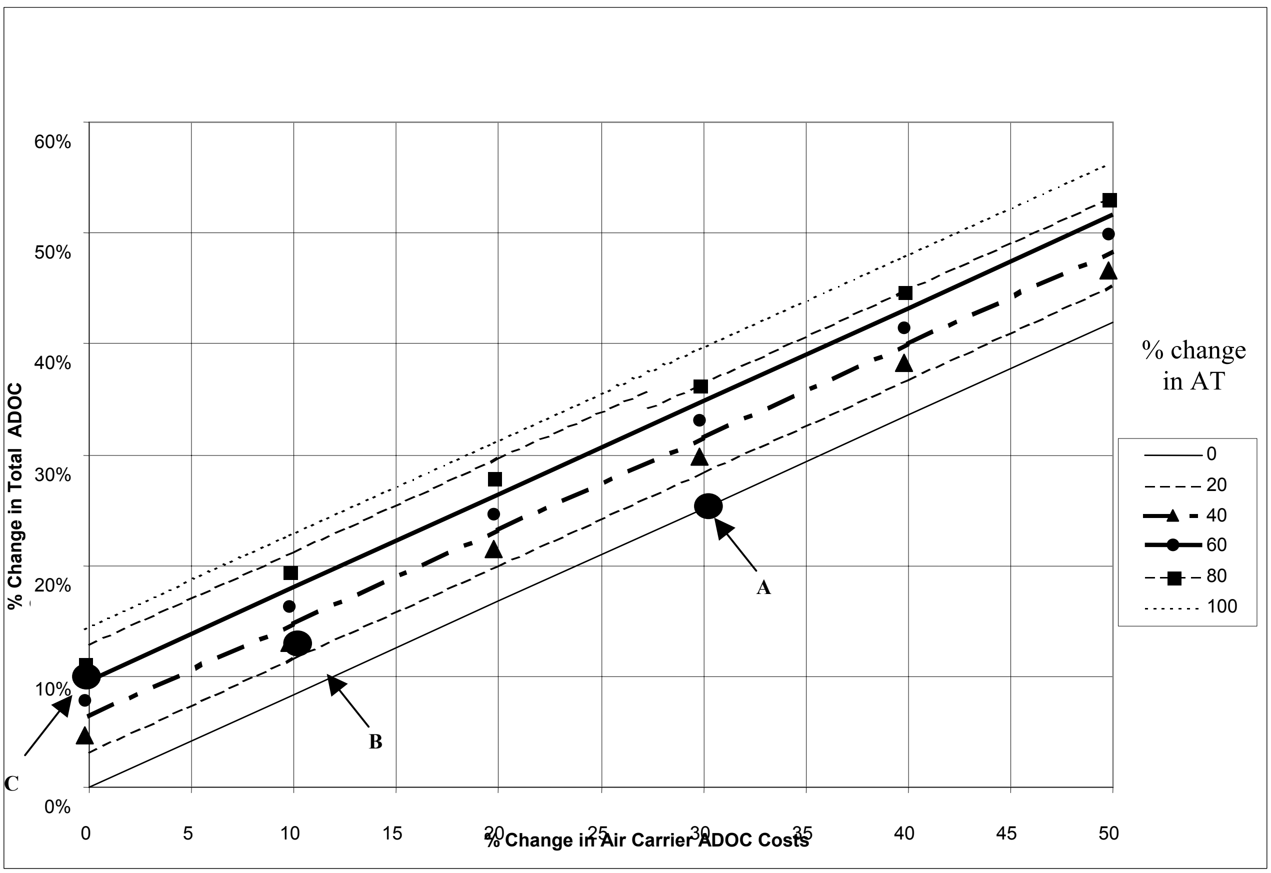


**Figure 2. ADOC Cost Sensitivity**

The additional ADOC due to delays are a function of the difference between the actual and scheduled gate-to-gate times. This difference in actual and scheduled gate-to-gate time is a measure of the time that fuel is being burned, crew are accumulating pay hours, and equipment is accumulating hours of use (maintenance costs are generally a function of equipment time or cycles, i.e., usage).

The inherent assumption is that there is no accumulation of ADOC prior to gate departure or after gate arrival, i.e., engines are not running, etc.

It is important to note that the average airborne time (wheels-off to wheels-on) accounts for over 80% of a typical flight in the NAS,[9] i.e., an average commercial or commuter flight in the NAS averages about 120 minutes (20 ground and 100 airborne). Yet, the majority of the delays (75-80%) are on the ground in the taxi-out phase. The remaining airborne time has significantly higher costs than are incurred on the ground; therefore, given that a flight is delayed and the majority of the delay is on the ground implies a lower ADOC than what is being applied in this report. Subsequent analysis will attempt to refine these costs.

### 3.7 Passenger Value of Time (PVT)

The PVT provides an estimate of the cost of delays to the passengers. The hourly PVT, per the FAA APO Publication 97-1, June 1997 - Treatment of Values of Passenger Time in Economic Analysis costs are as follows:

- Air carriers - $26.70 per block hour
- Air taxi/commuter - $34.50 per block hour
- General aviation - $31.10 per block hour

The average air carrier on board count of passengers was computed for each airport by dividing the air carrier enplanements from the TAF by one half the air carrier operations from the TAF (Equation 4). Similarly, the average on board count of passengers for air taxi/commuters was computed for airport by dividing the air taxi/commuter enplanements from the TAF by one-half the air taxi/commuter operations from the TAF (Equation 5).

4) $AC_{PAX/AC} = 2 * AC_{Enplanements} / AC_{OPS}$ (at airport i)

5) $AT_{PAX/AT} = 2 * AT_{Enplanements} / AT_{OPS}$ (at airport i)

In order to avoid "double counting," i.e., counting both the delay at a connecting point and the delay at the destination as an inconvenience to the passenger, the arrival delay cost was divided by a value of 1.6. This is an estimate obtained from the ATA of the number of legs the average

[9] This flight estimate is based on analysis using a March 1997 Enhanced Traffic Management (ETMS) data set. The flight times are based on the departure messages (DZ) and arrival messages (AZ) that have either an arrival or departure from one of the 80 busiest NAS airports.

passengers have on their trips (i.e., six of every ten passengers connect at a hub or four out of 10 passengers have deplaned after the first leg). Air taxi/commuters are included since the air taxi category included commuters, as well as the “on-demand” true air taxi flights.

An inherent assumption in this calculation is that passengers are concerned with their scheduled arrival time at their destination and not en route ATC inefficiencies or delays at connection points, provided they arrive at their destination on time. Another assumption is that small commuters and regionals have the same ratio of connecting passengers as air carriers. (The air carrier category includes the larger commuter aircraft with 60 or more seats).

## 4.0 WEATHER DELAYS

The frequency and cost of weather delays was computed as a percentage of the total delays. The below Methodology and Sensitivity Analysis sub-sections describe the transformation of the results discussed in the Total Delay section (Section 3.0). This paper accepts the findings documented in the literature on avoidable and unavoidable weather delay. Previous research work conducted by Mark Weber and Jim Evans at M.I.T Lincoln Laboratories[10] has indicated that slightly over 40% of the weather delay is avoidable given the amount of recoverable time is calculated from estimates of delays being impacted by either frontal passages, heavy fog, thunderstorms, and visibility.

Therefore, applying this "avoidable value", which has not been re-evaluated, confirmed, or validated in the subsequent years implies that roughly 17% of the delays (40% of delays minutes due to weather (per equation 6 from the ITWS CBA noted on the following page) * 40% of avoidable total delay time) can be reduced in a given year among the several acquisitions that are claiming delay benefits in poor weather conditions. With over 49 million minutes of ADOC delay reported at the 175 ASQP airports in 1996, about 8.5 million minutes of the total delay minutes represents a potential improvement for avoidable weather delay to the baseline. Note: the baseline is treated as scheduled block times in this analysis. The breakdown of non-weather related, unavoidable weather, and avoidable weather delay is portrayed in Figure 3 below.

[10] Memorandum, *Proportioning of Avoidable and Unavoidable Weather-Related Aviation Delays*, July 14, 1991.

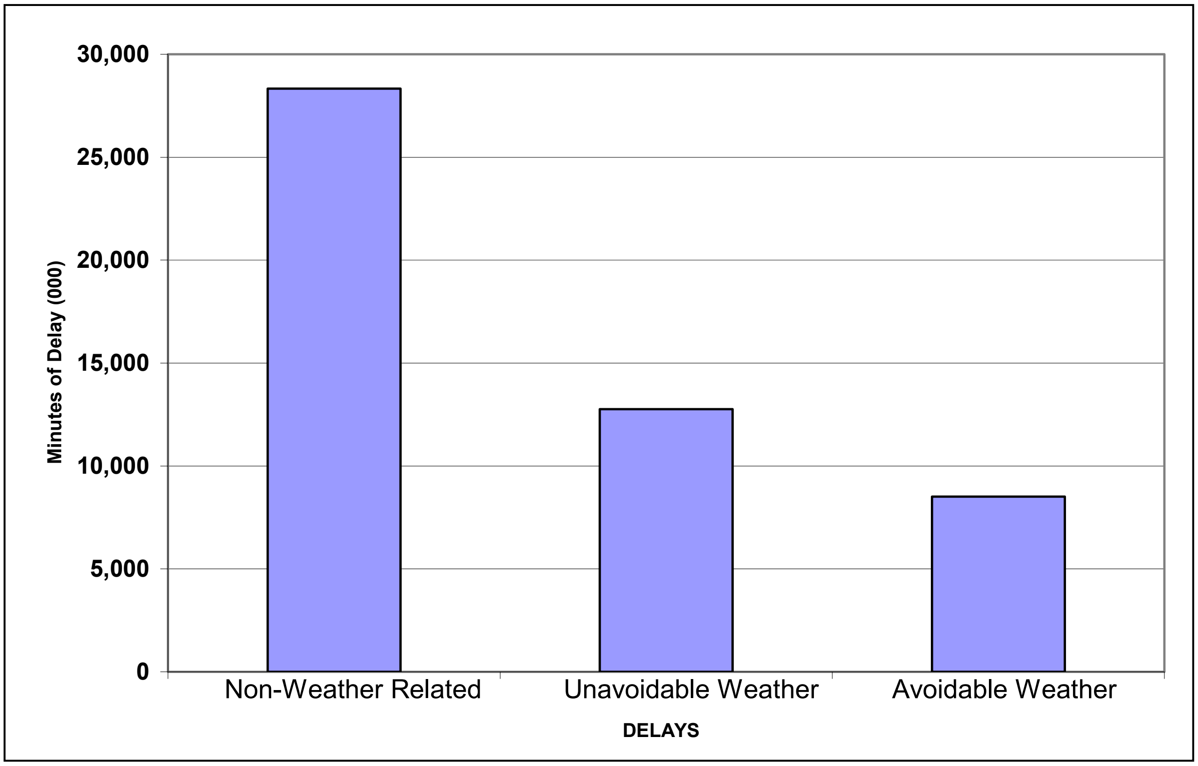


**Figure 3. Potential Cost Savings of Reducing Delays**

## 4.1 Methodology

Two methods were used to identify the proportion of the weather-related delays. These delay computations do not distinguish between avoidable and unavoidable delays.

**Method 1:** The percentage of all departure delays attributable to weather from OPSNET was used to compute the percentage of gate-to-gate delays that were considered weather delays. This factor was used as a result of an analysis that indicated that at each of the ASQP airports approximately 75 to 80% of the gate-to-gate delays were due to ground delays, either a gatehold or taxi delay. [11]

The percentage of all delays attributable to weather was derived from OPSNET. OPSNET identifies the cause of delays that are 15 minutes or more, equipment delays, weather delays, volume delays, runway delays, and other delays. Historically, the OPSNET reported weather delays have ranged from 60-70% given the delay is greater than 15 minutes. When OPSNET data were not available for either arrival or departure information, the OPSNET delay data at its 55 reporting airports were weighted by the factor at that airport. The weighted average of these airports was used for airports where OPSNET data were not available.

**Method 2:** The total delays were multiplied by factors developed from a legacy 1980's FAA delay database, the Standard Delay Reporting System (SDRS). These factors give the

[11] This duration of ground delay relative to airborne delay is consistent with several ASD-400 studies applied by the FAATC using NASPAC, a discrete event simulation model.

percentage of total delays that are weather delays for three distinct time intervals. The System Engineering and Integration Contract (SEIC) under the direction of ASD-400 (formerly AOR-100) applied these in the ITWS Cost Benefit Study, April 1995. The number of both types of delays by airport were segregated into the three intervals by: 1) delays less than 15 minutes were multiplied by 0.28; 2) the delays that were between 15 and 29 minutes were multiplied by 0.53; and 3) the delays that were in excess of 30 minutes were multiplied by 0.84. This equation is applied to each individual airport. Additional analysis is required to better identify these relationships by specific airport, yet, this estimate appeared to be a reasonable application, given the limited information for estimating weather delay.

$$6)\ WD_{ITWS} = \sum_{i=1}^{14} 0.28 \bullet n \bullet l + \sum_{i=15}^{29} 0.53 \bullet n \bullet l + \sum_{i=30}^{120} 0.84 \bullet n \bullet l$$

## 4.2 Sensitivity Analysis

Additional data were obtained to determine the sensitivity of the results to the assumptions that determined the percentage of total delays attributable to weather. Two separate @Risk analyses, that performed Monte Carlo sampling to approximate the input distributions, were done.

The additional data included an estimation of the percentage of time that an arrival airport was in Instrument Meteorological Conditions (IMC) for the purpose of establishing generic minimums. IMC is defined as the percentage of time that the airport was operating and had a ceiling of less than 1,000 feet or a visibility less than three miles. When data were available for either an airport's ceiling or visibility at one of the 175 airports in the study, the average IMC percentage of time for the NAS was used.

The data variables (five different percentages) used in the risk analysis were:

1) OPSNET arrival delays attributable to weather as a percentage of all delays reported in OPSNET,

2) OPSNET departure delays attributable to weather as a percentage of all delays reported in OPSNET,

3) The total OPSNET departure and arrival delays attributable to weather as a percentage of all delays reported in OPSNET,

4) The ITWS Cost Benefit Study factor, and

5) The percent IMC (as highlighted in the above paragraph).

These variables were arranged from highest to lowest. A median for each of the five data points was calculated.

The first @Risk analysis used a uniform distribution. The lowest and the highest datum point in the set of five data points were used in the simulation. The same distributions for an individual airport were used for both the ADOC and PVT calculations.

The second @Risk analysis used the triangular distribution. Three points were used: 1) the low datum point being the smallest datum point of the five variables, 2) the high being the highest datum point in the set, and 3) the most likely being the median of the five data points in the set. The same distributions for each airport were used for both the ADOC and PVT calculations.

## 5.0 RESULTS

### 5.1 Total Delay

This analysis applied accurate empirical data to identify the delay and delay cost for the vast majority of the delay contributing airports in the NAS. Additionally, the busiest airports that account for the majority of the NAS delay have been baselined from a starting year, 1996. An analyst can evaluate the ASQP data through ASD-400's Performance Monitoring Analysis Capability (PMAC) tool on a per flight basis or assess the total delay to measure the impact of new acquisitions, procedures, and runway improvements.

Table 4 summarizes the frequencies of the arrival delays and gate-to-gate delays that occurred in the NAS in 1996. Note: on-time performance that is reported by the airlines is considered to be any arrival delay that is less than 15 minutes.[12] It can be inferred from this table that given a delay occurs (≥ 1 minute), if it is a gate-to-gate delay, 82% of the time it will be a delay of less than 15 minutes, or if it is an arrival delay, 60% of the time it will be less than 15 minutes. 78.9% of the total events arrive on time. All flights that arrive less than 15 minutes within the schedule are considered to be "on time". This performance is consistent with DOT's published Air Travel Consumer Report (May 97 – April 98) of 79.1%. A breakdown of the delay distributions by airport is available upon request.

| | Gate-To-Gate Delay | | Arrival Delay | |
|---|---|---|---|---|
| **Amount of Delay** | **Frequency** | **Percent** | **Frequency** | **Percent** |
| No delay | 2,959,405 | 61.1 | 2,223,981 | 46.5 |
| 1-5 minutes | 820,695 | 16.9 | 700,368 | 14.6 |
| 6-10 minutes | 468,168 | 9.7 | 500,913 | 10.5 |
| 11-14 minutes | 250,368 | 5.3 | 347,574 | 7.3 |
| >=15 minutes | 347,315 | 7.2 | 1,010,128 | 21.1 |
| **Total Events** | **4,845,951** | | **4,783,764** | |

**Table 4. Summary of Delays in 1996 for 10 Major Carriers**

Note: The total events are different by approximately 62,000 flights (about 1%) because these events were dropped due to exceedingly long delays. Many of the delays are due to mechanical failures, very rare events, or outliers in the data.

[12] Office of Inspector General Audit Report, Air Carrier Arrival Data, Department of Transportation, FE-1998-103, March 30, 1998, pg. 1.

More results are shown in Table 5. This table suggests that the top airports, the majority of which are in the ASQP, are extrapolated accurately to account for the total air carrier and air taxi/commuter flights that arrive at those respective airports comprise the majority of the delay costs. Of the 175 ASQP airports evaluated, the 25 airports with the highest delay costs account for about 66% of the total delay costs.

| Delay Rank | Airport | G2G Delays (Delays in Minutes) AC | AT | ADOC Costs (AC + AT) | Arrival Delays (Delay in Minutes) AC | AT | PVT Costs (AC + AT) | Total Costs (PVT + ADOC) | Cum Costs (Percent) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ORD | 1,786,599 | 284,819 | 61,484,328 | 3,891,396 | 620,366 | 84,621,090 | 146,105,418 | 5.7% |
| 2 | ATL | 1,619,665 | 422,281 | 57,659,456 | 3,313,077 | 863,789 | 84,996,494 | 142,655,949 | 11.2% |
| 3 | LAX | 1,102,875 | 527,138 | 42,065,687 | 3,141,070 | 1,501,327 | 78,608,830 | 120,674,517 | 15.9% |
| 4 | DFW | 1,423,752 | 531,150 | 52,556,750 | 2,774,002 | 1,034,878 | 64,582,124 | 117,138,874 | 20.5% |
| 5 | SFO | 855,962 | 205,506 | 30,265,247 | 2,357,846 | 566,090 | 62,551,676 | 92,816,923 | 24.1% |
| 6 | EWR | 1,091,885 | 389,250 | 40,094,398 | 2,194,403 | 782,291 | 48,816,487 | 88,910,885 | 27.5% |
| 7 | STL | 827,918 | 267,203 | 30,074,440 | 2,010,627 | 648,911 | 42,676,623 | 72,751,064 | 30.4% |
| 8 | SEA | 547,232 | 347,182 | 21,874,421 | 1,567,125 | 994,235 | 42,789,987 | 64,664,407 | 32.9% |
| 9 | PHX | 624,161 | 153,554 | 22,112,479 | 1,788,200 | 439,926 | 40,374,657 | 62,487,136 | 35.3% |
| 10 | BOS | 577,988 | 508,813 | 24,766,883 | 1,348,355 | 1,186,980 | 36,441,260 | 61,208,143 | 37.7% |
| 11 | MIA | 792,387 | 406,182 | 30,544,304 | 1,754,838 | 899,540 | 29,982,318 | 60,526,621 | 40.0% |
| 12 | LAS | 442,019 | 123,157 | 15,828,314 | 1,449,098 | 403,752 | 41,124,393 | 56,952,708 | 42.2% |
| 13 | JFK | 688,140 | 360,458 | 26,616,129 | 1,570,712 | 822,761 | 28,458,204 | 55,074,333 | 44.4% |
| 14 | MSP | 645,294 | 259,029 | 24,034,610 | 1,311,606 | 526,496 | 30,974,951 | 55,009,561 | 46.5% |
| 15 | DTW | 652,613 | 187,349 | 23,434,029 | 1,430,816 | 410,751 | 31,513,600 | 54,947,629 | 48.6% |
| 16 | DEN | 444,662 | 152,080 | 16,252,774 | 1,386,164 | 474,085 | 36,508,955 | 52,761,729 | 50.7% |
| 17 | MCO | 401,991 | 232,556 | 15,805,662 | 1,099,106 | 635,844 | 33,395,169 | 49,200,832 | 52.6% |
| 18 | SLC | 454,406 | 210,440 | 17,252,898 | 1,139,426 | 527,679 | 30,187,992 | 47,440,890 | 54.5% |
| 19 | LGA | 529,400 | 178,695 | 19,322,343 | 1,224,676 | 413,380 | 27,519,998 | 46,842,341 | 56.3% |
| 20 | CVG | 457,974 | 470,528 | 20,412,590 | 908,675 | 933,584 | 23,655,742 | 44,068,332 | 58.0% |
| 21 | IAH | 563,604 | 145,575 | 20,048,064 | 1,149,590 | 296,931 | 23,808,069 | 43,856,133 | 59.7% |
| 22 | PHL | 420,660 | 264,637 | 16,788,698 | 1,125,818 | 708,252 | 24,535,684 | 41,324,382 | 61.3% |
| 23 | PIT | 440,415 | 259,845 | 17,375,624 | 1,138,369 | 671,637 | 23,271,671 | 40,647,295 | 62.9% |
| 24 | CLT | 432,112 | 200,808 | 16,414,513 | 1,121,755 | 521,294 | 23,831,184 | 40,245,697 | 64.4% |
| 25 | PDX | 242,203 | 257,236 | 10,893,586 | 737,192 | 782,946 | 21,437,866 | 32,331,452 | 65.7% |

**Table 5. 25 Most Costly Delayed Airports (All Flights) – Exclusive of GA**

An illustration using Atlanta Hartsfield (ATL) is read as follows. ATL experienced the second most total delay costs behind ORD in 1996, $142.6M. The ADOC minutes of delays (1,619,665 air carrier and 422,281 air taxi/commuter delay minutes) are the annual gate-to-gate delays. Similarly, the delays applied to PVT are the annual arrival delays (3,313,077 air carrier and 863,789 air taxi/commuter delay minutes). The highlighted cells are the delay minutes by air carrier, air taxi/commuter, and total costs.

Another way of looking at the results is illustrated in Figure 4. This figure provides an illustration of two sample distributions that were derived from the ASQP. Newark International Airport (EWR), an airport with very big delays, and Denver International Airport (DEN), an airport with moderate delays, are depicted. Both airports had about the same number of air carrier and air taxi/commuter operations in 1996; EWR had 423,968 operations (operations includes both an departure and an arrival on a flight) and DEN had 429,770 operations. The x-axis of 0-120 minutes represents the total minutes per time increment. Point A shows approximately 1,700 hours of arrival delay at EWR of 30 minutes. Point B shows approximately 1,400 hours of arrival delay at DEN of 30 minutes. Note: EWR delays remain considerably higher than DEN beyond 30 minutes. EWR's cumulative gate-to-gate and arrival delays clearly show more delay at DEN.

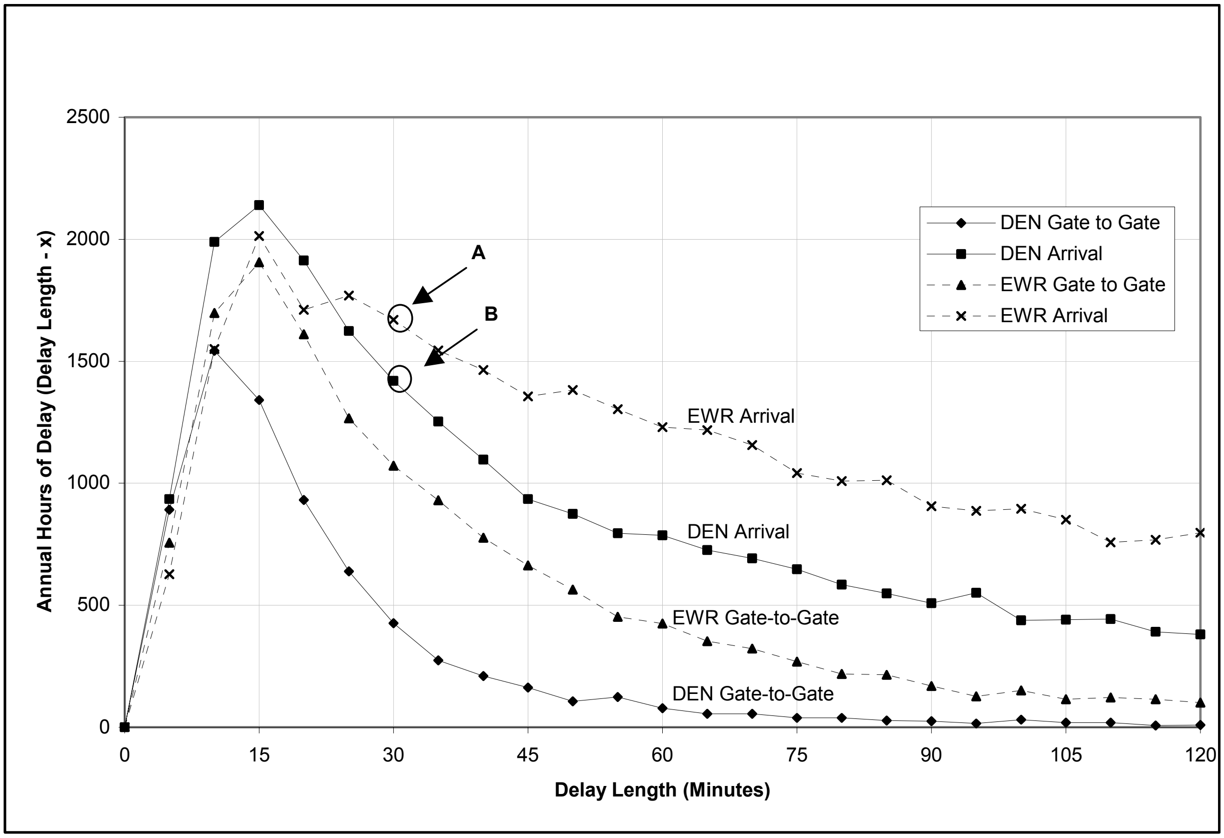


**Figure 4. Representative Delay Distribution (EWR and DEN)**

The results are summarized in Table 6. At EWR there was total of 102,926 ASQP arrivals, 16,133 arrivals (16%) reported were greater than 15 minute gate-to-gate delays, and 28,908 arrivals (28%) were delayed more than 15 minutes. Additional analysis is required so the aforementioned factors can be broken down to identify the amount of these delays that are caused by poor weather conditions.

| Airport | ASQP Arrivals | G-G Delays >15 Min | Arr Delays > 15 Min | % G-G Del >15 Min | % Arr Del >15 Min |
|---|---|---|---|---|---|
| EWR | 102,926 | 16,133 | 28,908 | 16 | 28 |
| DEN | 128,000 | 6,788 | 23,000 | 6 | 16 |

**Table 6. Comparison of Two Airports in 1996 (EWR and DEN)**

In contrast, out of a total of 128,000 ASQP arrivals to DEN, 6,788 flights (6%) reported gate-to-gate delays of greater than 15 minutes, and 23,000 flights (16%) reported greater than 15 minute arrival delays.

Figure 5 illustrates another way of assessing the behavior by examining the cumulative distribution of each airport's curve. Point A indicates that approximately 81% of the gate-to-gate delay time at DEN is from delays of 1-30 minutes; Point B shows 59% of the gate-to-gate delays range from 1-30 minutes at EWR.

Annual arrival delays average about 12.4 minutes per flight, 12.9 minutes at the 30 busiest airports (see Appendix F), gate-to-gate delays average about 3.4 minutes per airport, and 4.3 minutes at the 30 busiest airports.

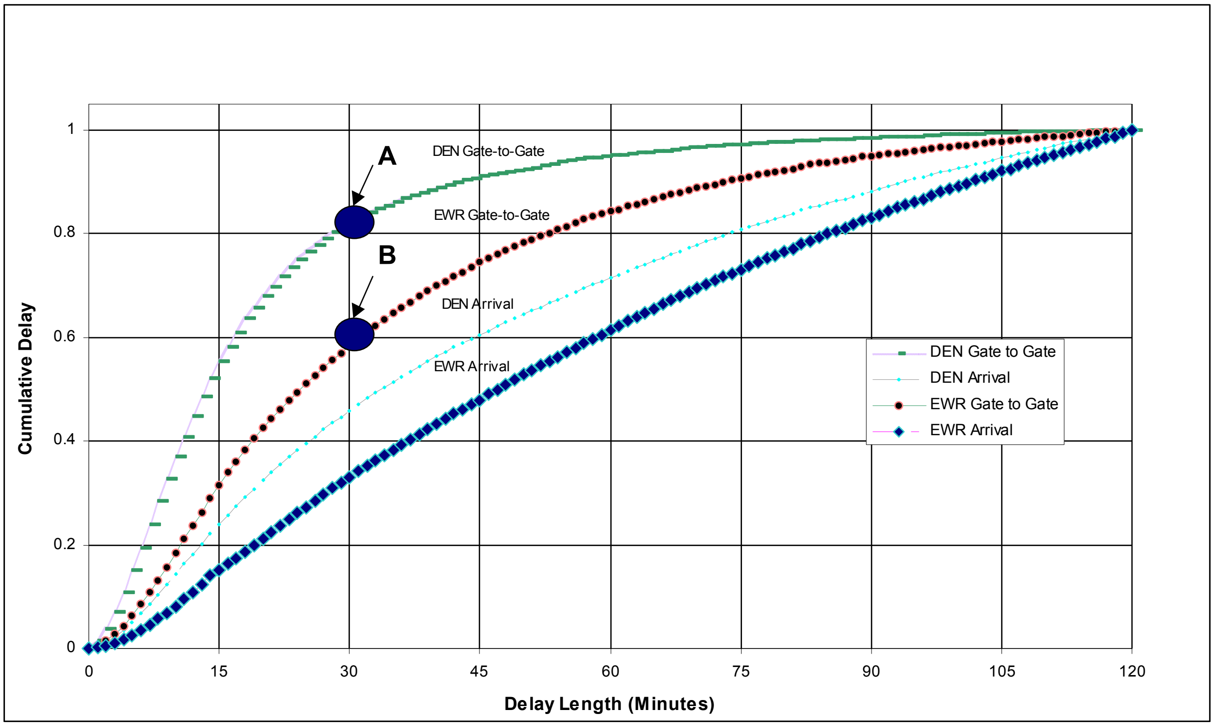


**Figure 5. Cumulative Delay Distribution (EWR and DEN)**

## 5.2 Weather Delay

The total delays and the weather delays resulting from the two different methodologies (OPSNET and ITWS Cost Benefit) and the two different sensitivity studies are shown below in Table 7. Because of the requirements of OPSNET reporting as previously described, the OPSNET results are significantly higher than the remaining results. The sensitivity studies indicate that the ITWS Cost Benefit methodology gives the more realistic of the two results although still overstated for the reasons previously explained. The variance in proportions between ADOC and PVT costs and total costs is due to the difference in distributions in the respective delays and the factors used to convert the total delays into weather delays. There are additional differences converting the delay times to delay costs further exacerbating the variance. Included in these differences is the difference in fleet mix between air carrier and air taxi/commuter and passenger loads, both of which attribute to ADOC and PVT cost differences between airports in the study.

| CASE | ADOC Delay Costs ($M) | PVT Delay Costs ($M) | Total Delay Costs ($M) | Total Delay (1996 Hours) | Percent of Total Delay Cost |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| *OPSNET* | 507 | 978 | 1,485 | 1,253,124 | 50.2% |
| *ITWS Study* | 367 | 833 | 1,200 | 1,034,728 | 39.4% |
| *Uniform Dist* | 407 | 656 | 1,064 | 800,274 | 35.9% |
| *Triang Dist* | 378 | 715 | 1,093 | 901,259 | 36.9% |
| **Total Delay** | 1,138 | 1,822 | 2,960 | 2,463,301 | 100.0% |

**Table 7. Summary of Weather Delays Relative to Total Delay**

The total 1996 NAS delay (flight delay and passenger delay) at the 400+ FAA towered airports for air carrier, air taxi/commuter, and GA operations is estimated at 147.8 million minutes or 2.46 million hours. The total delay cost is approximately $3.0B; ADOC $1.14B and PVT $1.82B. The total (ADOC plus PVT) delay cost of weather delays range from $1.09B to $1.48B depending on the method that is applied.

Table 8 gives a listing of the 25 airports with the highest weather delay costs. The cost of weather delays was determined by applying the factors used in the ITWS Cost Benefit method. These top 25 airports account for about 66% of the total weather delays at the ASQP airports.

| Delay Rank | Airport | G2G Delays (Delays in Minutes) AC | AT | ADOC Costs (Dollars) | Arrival Delays (Delay in Minutes) AC | AT | PVT Costs (Dollars) | Total Costs (Dollars) | Cum Costs (Percent) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ORD | 627,784 | 100,081 | 21,604,661 | 1,889,434 | 301,213 | 65,739,286 | 87,343,948 | 5.9% |
| 2 | LAX | 369,288 | 176,507 | 14,085,308 | 1,578,292 | 754,371 | 63,197,676 | 77,282,984 | 11.2% |
| 3 | ATL | 520,323 | 135,659 | 18,523,309 | 1,421,715 | 370,671 | 58,358,205 | 76,881,514 | 16.4% |
| 4 | SFO | 328,763 | 78,932 | 11,624,443 | 1,423,133 | 341,677 | 60,407,220 | 72,031,663 | 21.4% |
| 5 | DFW | 460,081 | 171,639 | 16,983,537 | 1,189,359 | 443,706 | 44,303,538 | 61,287,075 | 25.5% |
| 6 | EWR | 408,372 | 145,582 | 14,995,551 | 1,164,812 | 415,248 | 41,459,655 | 56,455,207 | 29.4% |
| 7 | STL | 267,223 | 86,244 | 9,706,968 | 946,238 | 305,390 | 32,135,042 | 41,842,010 | 32.2% |
| 8 | BOS | 210,751 | 185,528 | 9,030,722 | 671,302 | 590,959 | 29,028,655 | 38,059,378 | 34.8% |
| 9 | SEA | 167,740 | 106,420 | 6,705,036 | 716,985 | 454,879 | 31,323,379 | 38,028,416 | 37.4% |
| 10 | PHX | 187,419 | 46,108 | 6,639,805 | 751,121 | 184,788 | 27,134,557 | 33,774,362 | 39.7% |
| 11 | LAS | 132,967 | 37,048 | 4,761,436 | 638,388 | 177,870 | 28,987,227 | 33,748,664 | 42.0% |
| 12 | MIA | 265,746 | 136,223 | 10,243,779 | 797,489 | 408,797 | 21,800,804 | 32,044,583 | 44.2% |
| 13 | JFK | 241,444 | 126,472 | 9,338,662 | 780,136 | 408,646 | 22,615,250 | 31,953,912 | 46.4% |
| 14 | MCO | 131,529 | 76,091 | 5,171,517 | 512,621 | 296,556 | 24,920,688 | 30,092,204 | 48.4% |
| 15 | DEN | 135,177 | 46,232 | 4,940,843 | 579,113 | 198,064 | 24,404,409 | 29,345,253 | 50.4% |
| 16 | DTW | 205,375 | 58,958 | 7,374,607 | 612,544 | 175,846 | 21,585,965 | 28,960,572 | 52.4% |
| 17 | MSP | 201,002 | 80,685 | 7,486,515 | 553,917 | 222,350 | 20,930,130 | 28,416,645 | 54.3% |
| 18 | LGA | 183,753 | 62,024 | 6,706,721 | 560,212 | 189,095 | 20,141,862 | 26,848,582 | 56.2% |
| 19 | SLC | 136,584 | 63,254 | 5,185,835 | 472,990 | 219,046 | 20,050,279 | 25,236,114 | 57.9% |
| 20 | PHL | 137,219 | 86,324 | 5,476,453 | 501,889 | 315,739 | 17,500,804 | 22,977,257 | 59.4% |
| 21 | IAH | 177,191 | 45,767 | 6,302,912 | 463,396 | 119,692 | 15,355,127 | 21,658,038 | 60.9% |
| 22 | CVG | 141,817 | 145,705 | 6,321,008 | 358,452 | 368,278 | 14,930,676 | 21,251,684 | 62.4% |
| 23 | PIT | 134,694 | 79,469 | 5,314,056 | 455,967 | 269,020 | 14,914,121 | 20,228,176 | 63.7% |
| 24 | CLT | 132,519 | 61,583 | 5,033,970 | 441,904 | 205,359 | 15,020,905 | 20,054,874 | 65.1% |
| 25 | SAN | 67,797 | 27,905 | 2,533,262 | 379,649 | 156,264 | 16,330,357 | 18,863,619 | 66.4% |

**Table 8. Top 25 Cost of Weather Delay Airports (1996)**

National Airspace System Performance Analysis Capability (NASPAC), a discrete-event simulation model that models the contiguous airspace, results in support of future NAS modernization scenarios have shown increases of 2-3 minutes in both operational delay and passenger delay by year 2010.[13] This implies (in very simple terms) that delays will be increasing through 2010 as the demand growth (operations are projected to increase by 30%, enplanements by 58%) increases at a slightly faster rate than the projected NAS airport capacity.

Airport capacity will increase due to the following changes to the NAS: 1) AIP improvements, i.e., new runways and airport improvements, 2) Communications, Navigation and Surveillance/Air Traffic Management (CNS/ATM) improvements such as CTAS and ITWS, and 3) procedural improvements such as additional independent converging, parallel IFR approaches, and dependent converging instrument approaches. A detailed discussion of the derivation of future airport capacities can be found in the ASD-400/CSSI report Airport Capacity Impacts of Airport and CNS/ATM Improvements, September 1998.

### 5.3 Caveats

This study identifies and applies a methodology to baseline delays and their associated costs. There are a few "swing variables" that have a significant impact on the results and provide different numbers from previously done studies and analyses. They include variables that reduce the costs: 1) the application of the 60% deplanement factor for measuring PVT, 2) the reduction in the average PVT from about $46 per hour to $27 per hour for air carriers, 3) the application of ADOC to the gate-to-gate delays, which are about one-third the duration of the arrival delays, and 4) the difference in the lower ADOC ground costs and the higher ADOC airborne costs; the majority of the delay occurs on the ground.

Conversely, there are variables that can increase the study's estimated delay costs. These include: 1) inclusion of delays over 120 minutes, cancellations, and diversions, e.g., in 1997 ASQP carriers flying to ORD had 8,969 cancellations and 770 diversions, some that can be considered preventable; the inclusion of cancellations and diversions would give a "disruption cost", 2) additional unscheduled GA flights to non-towered airports, and 3) costs to account for the potential increased operating costs because of longer block times due to the present constraints of the ATC system.

The third variable noted in the preceding paragraph, the longer block times, requires additional analysis to measure the magnitude of the potential time improvement. If it is assumed that *every* scheduled air carrier and air taxi/commuter flight in the NAS can be reduced by one-minute of scheduled block time, then the airlines can conceivably reduce operating expenses by $300-$350M annually for each minute saved. This estimate assumes the weighted ADOC of the air carriers and air taxi/commuters is approximately $25 per minute, and between 30,000 (weekend) and 40,000 (weekday) of these flights, per the OAG, operate daily through the NAS. These flights include U.S. carriers that depart and arrive from international airports to/from U.S. airports.

[13] Development and Application of Performance Metrics for the National Airspace System, Current and Planned Systems, pp. 3-7.

Yet, this estimate of $300-$350M can be very deceptive and misleading. Since for each minute of reduction in block time, the potential cost savings per minute decreases considerably. For example there are approximately 50% fewer flights that can be reduced from an 8-minute lower block time to a 9-minute lower block time than can be reduced from a block time of 1-minute to a 2-minute lower block time). In other words, we must be very careful when calculating cost savings of the flights besides the flights that incur delays because their actual flight times are longer than the scheduled times. Applying the analysis discussed in Appendix A, (see figure A-1), each flight that has an actual block time identical or less than to it's scheduled block time (these flights account for 61% of all flights in the ASQP) has an associated cost savings if it arrives even earlier.

There are two fundamental questions that surface when putting a crude estimate on the impact of airline operating expenses due to a 1-minute reduction for every flight that is early as noted in the previous paragraph. The first question is: can an early arriving flight be expected to arrive even earlier in all cases because of changes in the NAS or are there other factors controlling the early arrival of flights? These factors may consist of, but not be limited to, issues such as meteorological conditions (jet stream, location, etc.). The second question is: are the cost savings linear with reductions in block time to factors such as fuel consumption, maintenance, and crew? If a very small percentage of the flights arrive more than 8 minutes before the scheduled flight time, can we make a claim that if this set of flights could potentially now arrive 9 minutes before the scheduled arrival time, there is a cost savings to the airlines? This type of rigorous evaluation is beyond the scope of this report. Regardless, there are other considerations such as optimal airborne speeds, aircraft characteristics, gate availability and general airline practices that determine how much an airline can expect to improve it's flight times within the current and planned NAS.

Figure 6 provides a conceptual look at how reductions to a flight's block times can potentially reduce the delay costs to the airlines relative to its schedule. With ADOC delays in 1996 estimated at $1.14B, the shaded region to the left of the thick vertical line roughly illustrates the potential additional cumulative dollar savings. This shaded region includes flights that already arrive early (per the schedule), from an additional 1 minute earlier up to 12 minutes before the scheduled gate-to-gate flight time. In other words, the shaded region represents the cost savings from being exactly on time to 1 minute early, 1 minute early to 2 minutes early, etc.

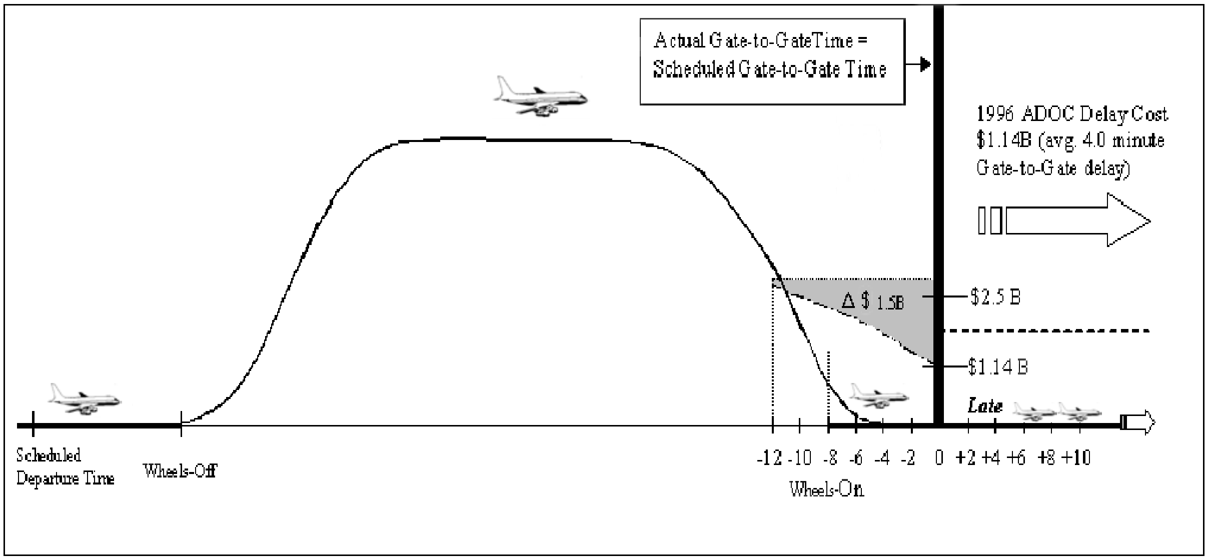


**Figure 6. Potential Cost Savings of Reduced Block Time**

While we are satisfied with the overall methodology used in this analysis, there is a reasonable level of risk in the accuracy of some of the variables that drive the results. Nevertheless, the delays and their associated costs (per the schedule) will not change substantially, i.e., gate-to-gate delays of slightly over 4 minutes and arrival delays of over 12 minutes.

### 5.4 Conclusion

In summary, the 1996 total cost of delay for air carrier, air taxi/commuter, and GA at 400+ towered airports is $2.96B ($1.14B in ADOC and $1.82B in PVT). Weather delays are estimated to be approximately $1.20B ($.367B in ADOC and $.833B in PVT). These results imply that of delays (as defined by the deviation from the schedule) caused by weather, approximately 40% of them are avoidable with weather "delays" historically occurring about 60-65% per of the time per OPSNET (this percentage is based on flights delayed more than 15 minutes). In 1996, using the ITWS Cost Benefit factors, there is a pool of 8.5 million minutes in gate-to-gate delays and 32 million minutes in arrival delays (measuring by aircraft, not passengers) attributed to bad weather that can be reduced with new technologies through capital investments, procedural improvements, runway improvements, and better scheduling.

## 6.0 NEXT STEPS

Several steps noted in the initial preliminary report (August 1998) have been taken and are reflected in this updated report. They include:

- Meet with other organizations that estimate delays to better understand their ground rules, assumptions, and methodologies. Consider computing ADOC delays by phase-of-flight delays computed through the Consolidated Operations and Delay Analysis System (CODAS)

- Continue to solicit feedback from APO, academia, and other FAA and non-FAA organizations on the methodology used in this analysis.

- Refine the factors used in converting delay hours to costs, particularly the ADOC for air taxi/commuters. See Section 3.6 where the updated costs are shown.

- Evaluate the delay distribution of the air taxi/commuters and non-ASQP carriers relative to the ASQP air carriers. See Appendix A.

Steps that require additional follow-up work include:

- Identify and measure flight efficiency in concurrence with the recent C/AFT group recommendations. Gain better insights of the relationship between delays, block times and flight time changes between city pairs. ASD-400/SETA will be evaluating this problem in FY99 and FY00 and notes it in Section 5.3.

- Develop a better estimate for the amount of avoidable and unavoidable weather delay. This work can provide a more realistic range of benefits that individual programs and airport improvements can take credit for.

- Refine the model into a more automated process so that "what-ifs" can be done to measure delay changes based on range estimates of key factors and more current years.

- Extend the analysis to evaluate the cost impact of cancellations and diversions to both the airlines and the passengers.

## APPENDIX A: COMPARING ASQP AND NON-ASQP AIR CARRIERS AND AIR TAXI/COMMUTER DELAY DISTRIBUTIONS

This section compares gate-to-gate delay (flight delay) and arrival delay distributions for air taxi/commuters, non-ASQP, and ASQP air carriers. Gate-to-gate and arrival delays are defined earlier in Section 3.2.1. When performing operational analyses, ASQP data are frequently used as the primary delay data source because it provides applicable timestamps for a relatively large set of flights in the NAS. ASD-400 maintains ASQP data from January 1995 to present. These data are often used to measure different metrics such as delays in support of several ASD-400 functions, including investment analyses, operational analyses, and performance measurement. Since ASQP contains operational data of 10 major airlines (as referenced in Section 3.1) the results are normally extrapolated to cover the entire NAS (i.e., total operations).

In this report, delays are calculated using ASQP data and then extrapolated to include non-ASQP air carriers and air taxi/commuters. By doing so, it is assumed that ASQP air carriers and non-ASQP air carriers and air taxi/commuters have the same pattern (i.e., same distributions) for the given metric under study. This assumption, although used frequently, has not been studied formally. This appendix attempts to justify this assumption. Here, we start by comparing delay and demand distributions for ASQP and non-ASQP air carriers and point out similarities and differences. Furthermore, statistical tests show that there are no significant differences between ASQP and non-ASQP delay distributions and ASQP and air taxi/commuter delay distributions given that the taxi time distributions are the same.

In order to compare ASQP to non-ASQP air carriers and air taxi/commuters, we used the Consolidated Operations and Delay Analysis System (CODAS), a database that was developed by the Office of Aviation Policy and Plans (APO). It has detailed operational information for the three categories described above. It currently contains almost all domestic air taxi/commuter and air carrier flight information. CODAS derives air taxi/commuter and non-ASQP air carrier operational information from the Enhanced Traffic Management System (ETMS). There is a drawback in using CODAS. Not all measures related to air taxi/commuters and non-ASQP air carriers in CODAS are actual, but rather, estimated. However, currently, no better alternative exists for estimating these flight times and other flight timestamps. That is, this difference can affect non-ASQP and air taxi/commuter distributions. More specifically, scheduled and actual arrival times are required to calculate arrival delays. Similarly, flight and gate-to-gate times are required to calculate gate-to-gate delays. All of these measures are known for ASQP air carriers but need to be estimated for air taxi/commuters and non-ASQP air carriers.

These measures need to be estimated because the only pertinent timestamps that can measure air taxi and non-ASQP flights are the AZ and DZ messages from the host computre that are processed through the ETMS. Nominal taxi-in and taxi-out times are used to calculate the arrival and departure times of non-ASQP air carriers and air taxi/commuters. Furthermore, median taxi times by airport and time of day are used to calculate the actual arrivals and departures of non-ASQP air carriers and air taxi/commuters. In short, CODAS assumes that nominal and actual taxi time distributions are the same for both air carriers and air taxi/commuters. If this assumption is wrong, then the estimated distributions will not be correct. That is, they will not reflect the real delay distributions of air taxi/commuters and non-ASQP air carriers.

## Results

Figures A-1 and A-2 represent the zoomed versions around their means of overall gate-to-gate delay and arrival delay distributions, respectively, of air taxi/commuters, non-ASQP and ASQP air carriers using 9 months of data. These figures reflect flights arriving between 60 minutes early and 120 minutes late; this occurs at least 99% of the time. Visual inspection of the delay distributions leads one to suspect that they all have similar characteristics, shapes, and perhaps all come from the same distribution.

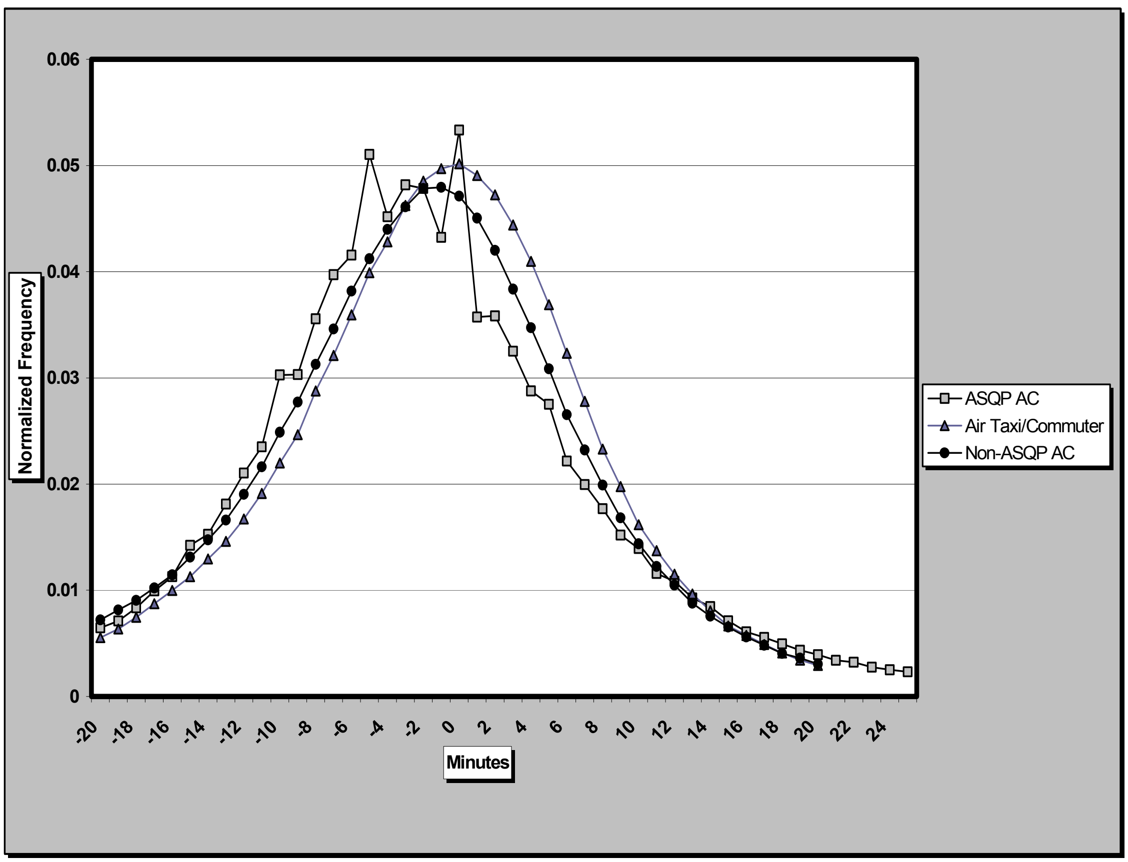


**Figure A-1. Truncated Flight Delay**

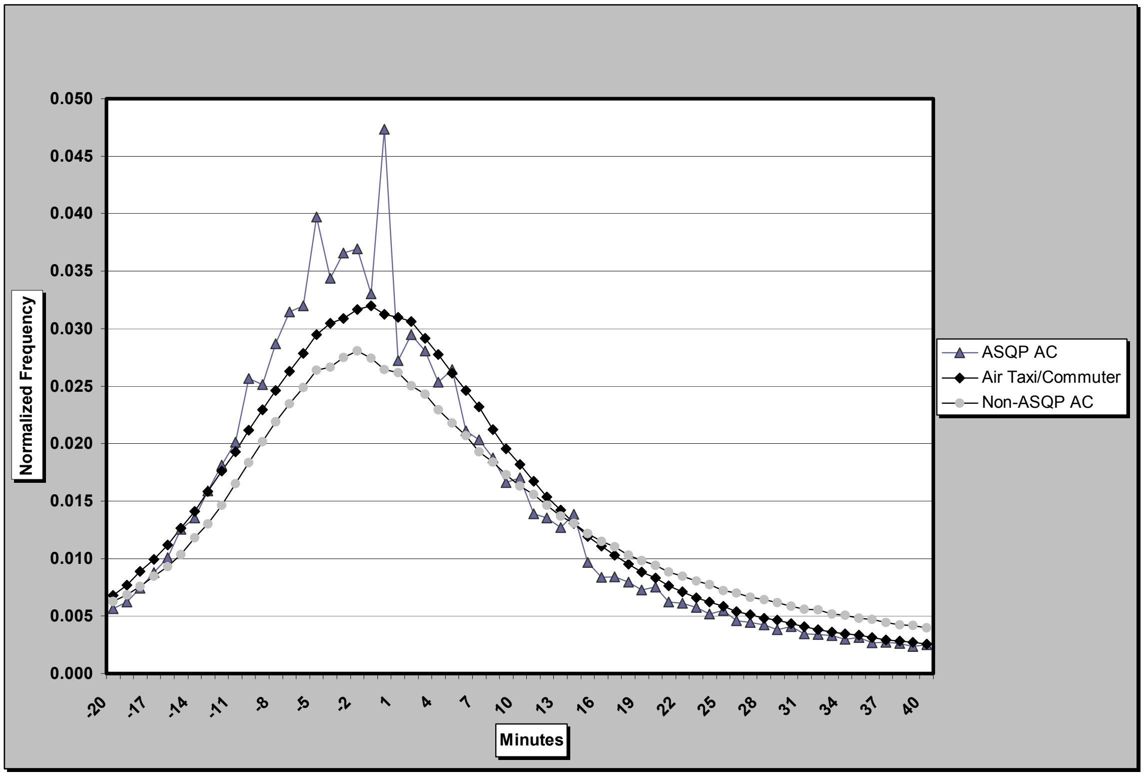


**Figure A-2. Truncated Arrival Delay**

We also studied the hourly actual and scheduled departure and arrival distributions of air taxi/commuters, non-ASQP, and ASQP air carriers using the same data source (9 months of CODAS data). Figures A-3 and A-4 display two samples of these distributions. Scheduled and actual hourly demands (arrivals and departure) for the three data sets follow similar patterns. By looking at the data, one can casually conclude that there are no significant differences in delay and demand distributions between ASQP air carriers and non-ASQP air carriers and air taxi/commuters. Thus, estimating delays using CODAS data will produce very similar results to those currently obtained by using ASQP air carriers and extrapolating to include non-ASQP air carriers and air taxi/commuters.

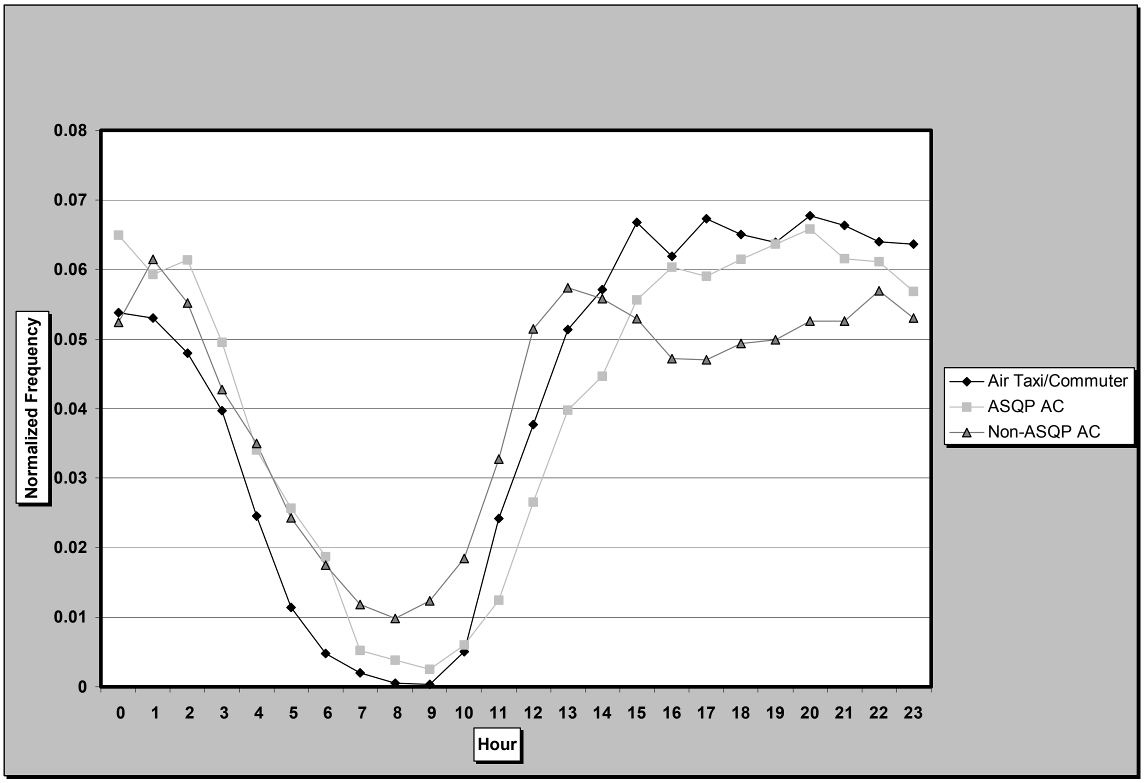


**Figure A-3. Scheduled Hourly Arrival Distribution for Air Taxi/Commuter and ASQP and Non-ASQP Air Carriers (GMT Hours)**

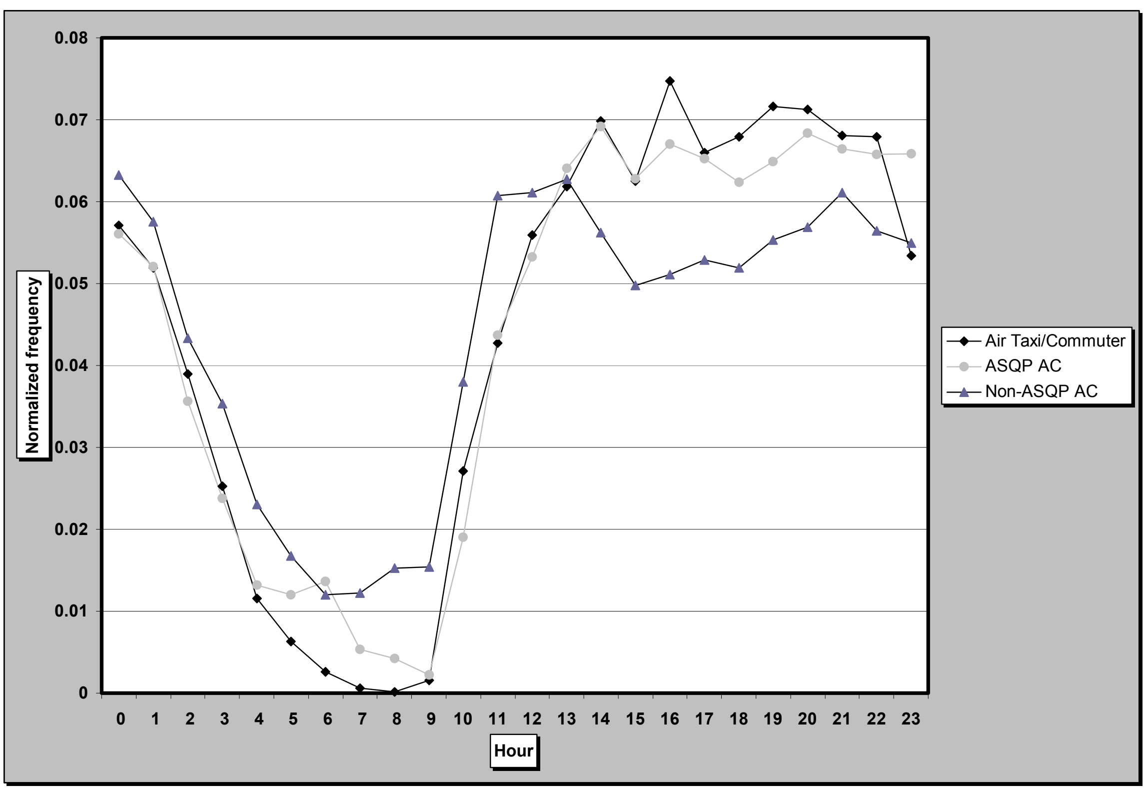


**Figure A-4. Scheduled Hourly Departure Distribution for Air Taxi/Commuter and ASQP and Non-ASQP Air Carriers (GMT Hours)**

Figures A-5 and A-6 compare the distributions for conditional arrival and gate-to-gate delays, which are defined to be positive delays of up to 120 minutes (a maximum of 120 minutes is used to be consistent with the assumptions made in this report). These figures show an interesting pattern. ASQP air carriers have a greater proportion of arrival delays of less than 15 minutes compared to non-ASQP carriers. Contrarily, the opposite is true for the gate-to-gate delays of less than 10 minutes. In both cases, the situation is reversed for flights greater than 15 or 10 minutes, respectively. The ASQP carriers' arrival delay pattern can be explained by the airline's commitment to meet DOT's on-time criterion: all delays of less than 15 minutes are considered on time. Thus, these airlines try to reduce delays of greater than 15 minutes. The differences in gate-to-gate delay patterns can be explained by the fact that ASQP airlines (bigger airlines) better estimate their scheduled flight times. Thus, most of the time (i.e., around 68% of gate-to-gate delays are less than 10 minutes) the duration of their gate-to-gate delay figures is less than those of non-ASQP air carriers and air taxi/commuters. The crossing of the gate-to-gate delay distributions can be explained by the greater variability of ASQP air carriers' routes (i.e., they fly longer routes, leading to larger gate-to-gate delays). Furthermore, ASQP air carriers have larger variances, which is another indication of higher variability.

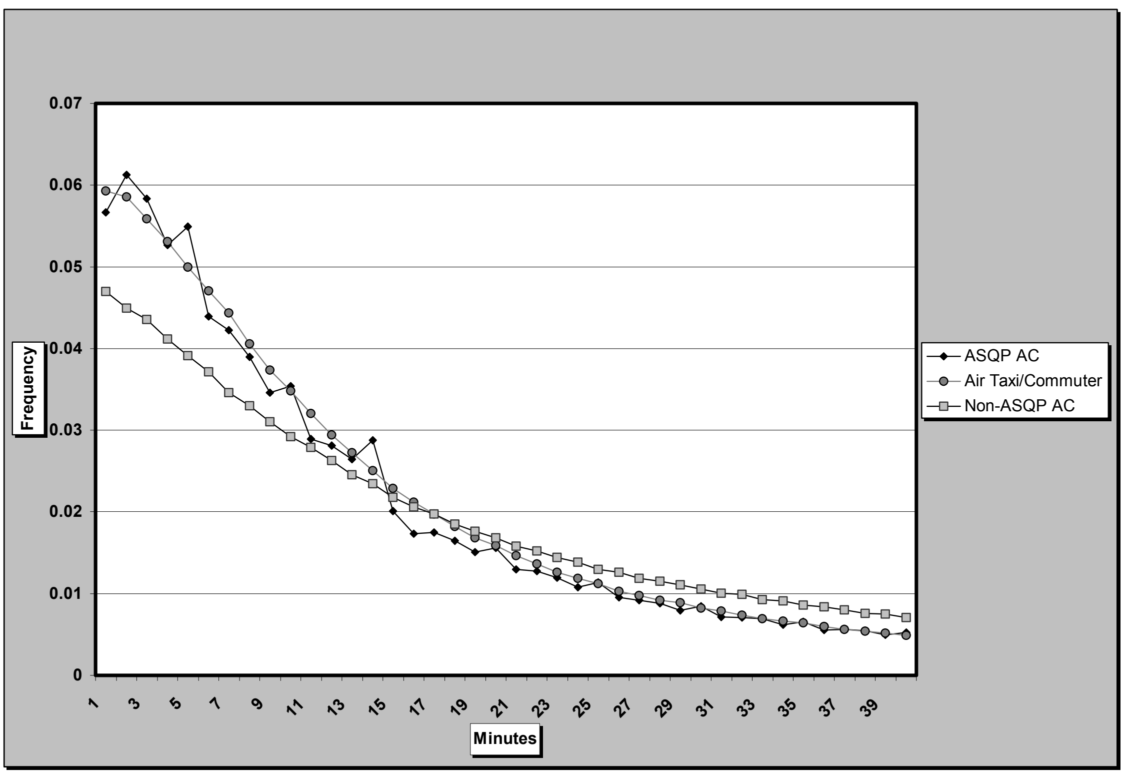


**Figure A-5. Conditional Arrival Delay Distribution**

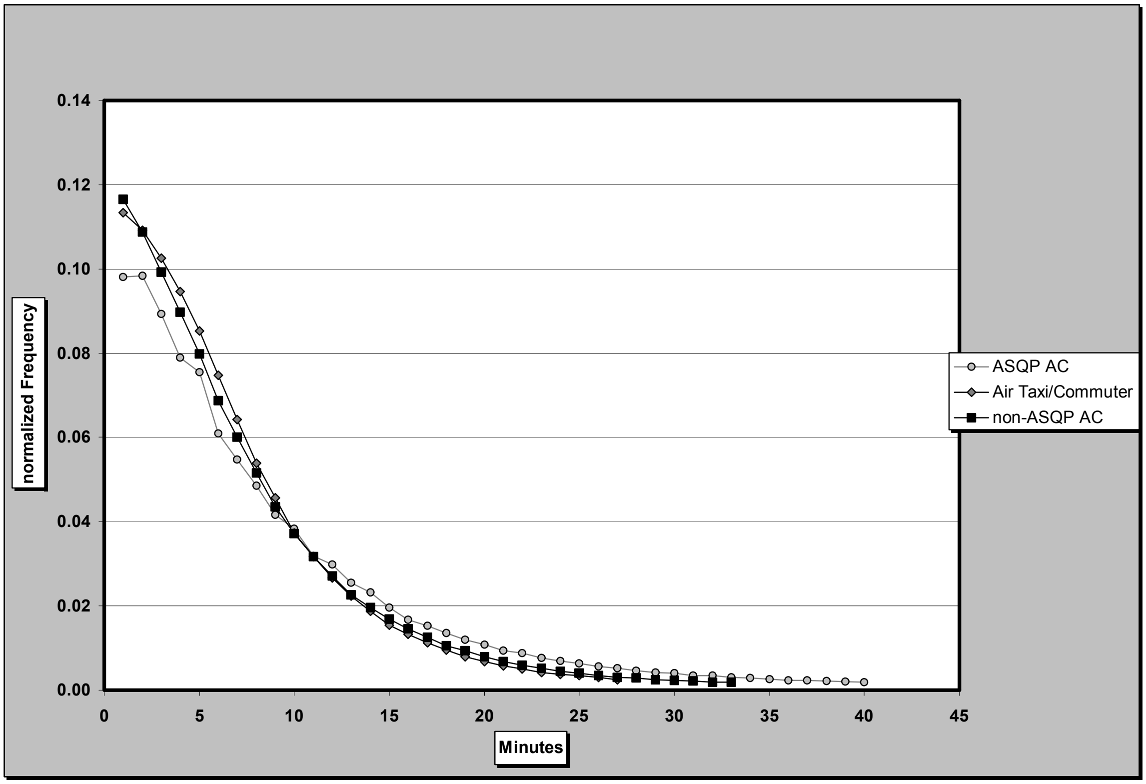


**Figure A-6. Conditional Gate-to-Gate Delay**

Thus, we conclude that it would be beneficial to break the data into two sets for each type of delay: 1) less than 15 minutes and greater than 15 minutes for arrival delays, and 2) less than 10 minutes and greater than 10 minutes for gate-to-gate delays; and study each set separately.

**Statistical Analysis**

The overall distributions of delays for the three data sets of data (ASQP, non-ASQP, and air taxi/commuters) can be compared to see if they come from the same distribution using nonparametric techniques. Nonparametric techniques are actually more powerful in this case (Reference 2) than parametric techniques like the chi-squared goodness-of-fit test. The well-known nonparametric Kolmogorov-Smirnov goodness-of-fit test was used to see if arrival and gate-to-gate delay distributions for air taxi/commuters and non-ASQP air carriers are the same as arrival and gate-to-gate delay distributions for ASQP air carriers. This test does not reject these hypotheses. Thus, we can conclude that delay for air taxi/commuters and non-ASQP air carriers have the same distribution as ASQP air carriers. The hypotheses and summary of results are summarized in Table A-1.

$$H_0 : F(x) = F_0(x)$$
$$H_A : F(x) \neq F_0(x)$$

Where $F(x)$ is the cumulative density function (CDF) of non-ASQP or air taxi delay data and $F_0(x)$ is the CDF of ASQP delay data. $H_0$ is the null hypothesis that non-ASQP or air taxi/commuters have the same delay distribution as ASQP airlines. $H_A$ is the alternative hypothesis that the distributions are different for at least some $x$. the test statistics is $t$:

$$t = \sup|F_0(x) - S(x)|$$

where $S(x)$ is the sample CDF based on the observations and sup is the supremum (maximum) function.

The decision rules reject the null hypothesis if $t$ is greater than the values given in Table A-1. The values of $t$ are captured in Table A-2.

| Type I error | $\alpha$ | 0.10 | 0.05 | 0.02 | 0.01 |
|---|---|---|---|---|---|
| n | 120 | 0.11 | 0.12 | 0.14 | 0.15 |

**Table A-1. Critical Values**

| | G2G Delay | | Arrival Delay | |
|---|---|---|---|---|
| | Non ASQP | Air Taxi | Non ASQP | Air taxi |
| $t$ | 0.072 | 0.097 | 0.108 | 0.025 |

**Table A-2. Value of Test Statistics**

## Descriptive Statistics

One can compare the means of the distributions (the delays for the three categories) for statistically significant differences using the Student-$t$ test. However, the large sample sizes (several million observations) almost guarantee the finding of a significant difference in the mean, however small. Thus, an *insubstantive difference of less than one minute* may be found. If this is the case, there is no practical difference in the means. Therefore, these distributions can be considered the same. This problem has been considered in the literature, see McCloskey and Ziliak (1996) for a survey.

Tables A-3 and A-4 list the means and standard deviations for gate-to-gate and arrival delays, respectively. The differences in the means of arrival and gate-to-gate delays are less than 1 minute except for gate-to-gate delays of over 15 minutes.

| Type | G2G Delay | | | |
|---|---|---|---|---|
| | <10 Minutes | | >=10 Minutes | |
| | mean | Std | mean | Std |
| ASQP AC | 4.28 | 2.47 | 20.71 | 13.35 |
| Non-ASQP AC | 4.22 | 2.46 | 18.66 | 11.44 |
| Air Taxi/Comm. | 4.28 | 2.45 | 17.37 | 9.78 |

**Table A-3. Gate-to-Gate Delay Statistics**

| Type | Arrival Delays | | | |
|---|---|---|---|---|
| | <15 Minutes | | >=15 Minutes | |
| | mean | Std | mean | Std |
| ASQP AC | 6.39 | 3.91 | 39.36 | 24.72 |
| Non-ASQP AC | 6.62 | 3.96 | 38.68 | 22.05 |
| Air Taxi/Comm. | 6.42 | 3.88 | 35.27 | 20.96 |

**Table A-4. Arrival Delay Statistics**

**Reference:**

[1] McCloskey, Deirdre N. and Ziliak, Stephen T., "The Standard Error of Regression," *Journal of Economic Literature*, 36, 1996, 97-114.

[2] Pfaffenberger, Roger C. and Patterson, James H., *Statistical Methods for Business and Economics*, IRWIN, Illinois, Third Edition, 1987.

# APPENDIX B: 175 ASQP AIRPORTS – 1996 OPERATIONS

| Code | Description | AC Ops | AT Ops | Total Ops |
|---|---|---|---|---|
| ABE | Lehigh Valley International Airport (Allentown, PA) | 17579 | 17201 | 84611 |
| ABQ | Albuquerque International Airport (Albuquerque, NM) | 86901 | 35185 | 190057 |
| AGS | Bush Field Airport (Augusta,GA) | 4225 | 9325 | 33346 |
| ALB | Albany County Airport (Albany, NY) | 23574 | 63135 | 125708 |
| AMA | Amarillo International Airport (Amarillo, TX) | 11735 | 9239 | 49152 |
| ATL | Atlanta International Airport (Atlanta, GA) | 592353 | 154439 | 772588 |
| AUS | Austin Robert Mueller Municipal Airport (Austin, TX) | 80136 | 21200 | 208995 |
| AVL | Asheville Regional Airport (Asheville, NC) | 6175 | 11450 | 52468 |
| AVP | Wilkes-Barre/Scranton International Airport (Wilkes-Barre/Scranton, PA) | 6624 | 14314 | 42226 |
| AZO | Kalamazoo/Battle Creek International Airport (Kalamazoo, MI) | 6379 | 20370 | 63878 |
| BDL | Bradley International Airport (Windsor Locks, CT) | 56716 | 56917 | 158252 |
| BFL | Meadows Field Airport (Bakersfield, CA) | 993 | 23733 | 104132 |
| BGM | Binghamton Regional/Edwin A Link Field Airport (Binghamton, NY) | 2683 | 20404 | 36113 |
| BGR | Bangor International Airport (Bangor, ME) | 6435 | 23934 | 62392 |
| BHM | Birmingham International Airport (Birmingham, AL) | 41480 | 23770 | 152016 |
| BIL | Billings Logan International Airport (Billings, MT) | 10051 | 34164 | 77329 |
| BIS | Bismarck Municipal Airport (Bismarck, ND) | 3754 | 15253 | 42206 |
| BNA | Nashville International Airport (Nashville, TN) | 91845 | 68358 | 226246 |
| BOI | Boise Air Terminal/Gowen Field Airport (Boise, ID) | 38502 | 31096 | 146483 |
| BOS | General Edward Lawrence Logan International Airport (Boston, MA) | 230602 | 203003 | 462507 |
| BTR | Baton Rouge Metropolitan, Ryan Field Airport (Baton Rouge, LA) | 10051 | 22314 | 85988 |
| BTV | Burlington International Airport (Burlington, VT) | 7591 | 44849 | 86407 |
| BUF | Greater Buffalo International Airport (Buffalo, NY) | 43727 | 46331 | 134498 |
| BUR | Burbank-Glendale-Pasadena Airport (Burbank, CA) | 59823 | 37212 | 180547 |
| BWI | Baltimore/Washington International Airport (Baltimore, MD) | 150509 | 87782 | 261825 |
| BZN | Gallatin Field Airport (Bozeman, MT) | 4548 | 5928 | 17964 |
| CAE | Columbia Metropolitan Airport (Columbia, SC) | 23933 | 20173 | 84443 |
| CAK | Akron-Canton Regional Airport (Akron, OH) | 9284 | 13924 | 79144 |
| CHA | Lovell Field Airport (Chattanooga, TN) | 7616 | 13986 | 69924 |
| CHS | Charleston AFB/International Airport (Charleston, SC) | 25938 | 5132 | 84724 |
| CID | The Eastern Iowa Airport (Cedar Rapids, IA) | 14495 | 18473 | 64354 |
| CLE | Cleveland-Hopkins International Airport (Cleveland, OH) | 145362 | 112324 | 290369 |
| CLT | Charlotte/Douglas International Airport (Charlotte, NC) | 268596 | 124820 | 457054 |
| CMH | Port Columbus International Airport (Columbus, OH) | 80757 | 63344 | 185459 |
| COS | City of Colorado Springs Muni Airport (Colorado Springs, CO) | 56890 | 10353 | 138353 |
| CRP | Corpus Christi International Airport (Corpus Christi, TX) | 15017 | 16997 | 83300 |
| CRW | Yeager Airport (Charleston, WV) | 5685 | 23587 | 69015 |
| CVG | Cincinnati/Northern Kentucky Intl Airport (Covington/Cincinnati, OH, KY) | 186302 | 191409 | 393523 |
| DAB | Daytona Beach Regional Airport (Daytona Beach, FL) | 8360 | 2981 | 214866 |
| DAL | Dallas Love Field Airport (Dallas, TX) | 99508 | 26482 | 220579 |
| DAY | James M Cox Dayton International Airport (Dayton, OH) | 70746 | 27394 | 144773 |
| DCA | Washington National Airport (Washington, DC) | 176339 | 80078 | 309754 |
| DEN | Denver International Airport (Denver, CO) | 320243 | 109527 | 454210 |
| DFW | Dallas/Fort Worth International Airport (Dallas-Fort Worth, TX) | 612269 | 228415 | 869831 |
| DLH | Duluth International Airport (Duluth, MN) | 4151 | 7816 | 37548 |
| DRO | Durango-La Plata County Airport (Durango, CO) | 700 | 12500 | 25756 |
| DSM | Des Moines International Airport (Des Moines, IA) | 34258 | 28048 | 123820 |
| DTW | Detroit Metropolitan Wayne County Airport (Detroit, MI) | 349630 | 100370 | 531098 |

| | | | | |
|---|---|---|---|---|
| EGE | Eagle County Regional Airport (Vail/Eagle, CO) | 1976 | 1121 | 20059 |

## APPENDIX B: 175 ASQP AIRPORTS – 1996 OPERATIONS, Cont.

| Code | Description | AC Ops | AT Ops | Total Ops |
|---|---|---|---|---|
| ELM | Elmira/Corning Regional Airport (Elmira, NY) | 2646 | 13240 | 35160 |
| ELP | El Paso International Airport (El Paso, TX) | 60457 | 11580 | 127047 |
| ERI | Erie International Airport (Erie, PA) | 2887 | 8047 | 34689 |
| EUG | Mahlon Sweet Field Airport (Eugene, OR) | 6307 | 23375 | 74176 |
| EWR | Newark International Airport (Newark, NJ) | 312547 | 111421 | 443431 |
| FAR | Hector International Airport (Fargo, ND) | 6070 | 11541 | 54195 |
| FAT | Fresno Yosemite International Airport (Fresno, CA) | 11497 | 58449 | 142419 |
| FAY | Fayetteville Regional/Grannis Field Airport (Fayetteville, NC) | 4823 | 7365 | 37160 |
| FCA | Glacier Park International Airport (Kalispell, MT) | 2050 | 9400 | 66490 |
| FLL | Fort Lauderdale/Hollywood International Airport (Fort Lauderdale, FL) | 100145 | 60999 | 234474 |
| FSD | Joe Foss Field Airport (Sioux Falls, SD) | 11281 | 18356 | 64842 |
| FWA | Fort Wayne International Airport (Fort Wayne, IN) | 12761 | 22460 | 72964 |
| GEG | Spokane International Airport (Spokane, WA) | 45127 | 41550 | 108046 |
| GFK | Grand Forks International Airport (Grand Forks, ND) | 3760 | 8172 | 75873 |
| GNV | Gainesville Regional Airport (Gainesville, FL) | 3170 | 14870 | 62158 |
| GRB | Austin Straubel International Airport (Green Bay, WI) | 10479 | 10766 | 35511 |
| GRR | Kent County International Airport (Grand Rapids, MI) | 24058 | 37602 | 111735 |
| GSO | Piedmont Triad International Airport (Greensboro, NC) | 56126 | 33375 | 138883 |
| GSP | Greenville-Spartanburg International Airport (Greer, SC) | 21164 | 17532 | 58064 |
| GTF | Great Falls International Airport (Great Falls, MT) | 6920 | 14609 | 39446 |
| GUC | Gunnison County Airport (Gunnison, CO) | 810 | 4950 | 19910 |
| HDN | Yampa Valley Airport (Hayden, CO also Steamboat Springs & Craig.) | 3013 | 7505 | 13408 |
| HLN | Helena Regional Airport (Helena, MT) | 1978 | 14729 | 39428 |
| HOU | William P. Hobby Airport (Houston, TX) | 118272 | 19344 | 251721 |
| HPN | Westchester County Airport (White Plaines, NY) | 11182 | 35210 | 153669 |
| HRL | Rio Grande Valley International Airport (Harlingen, TX) | 12032 | 7601 | 44328 |
| HSV | Huntsville International-Carl Jones Field Airport (Huntsville, AL) | 13755 | 9821 | 53644 |
| HVN | Tweed-New Haven Airport (New Haven, CT) | 819 | 11225 | 40485 |
| IAD | Washington Dulles International Airport (Washington, DC) | 90945 | 177953 | 330341 |
| IAH | George Bush Intercontinental Airport (Houston, TX) | 292203 | 75474 | 391939 |
| ICT | Wichita Mid-Continent Airport (Wichita, KS) | 31576 | 17550 | 151058 |
| IDA | Fanning Field Airport (Idaho Falls, ID) | 2089 | 10000 | 27845 |
| ILM | New Hanover International Airport (Wilmington, NC) | 4554 | 15052 | 48211 |
| IND | Indianapolis International Airport (Indianapolis, IN) | 108612 | 71570 | 231972 |
| ISP | Long Island MacArthur Airport (Islip, NY) | 10598 | 23737 | 112324 |
| ITH | Tompkins County Airport (Ithaca, NY) | 1976 | 11994 | 32966 |
| JAC | Jackson Hole Airport (Jackson, WY) | 3840 | 9982 | 31392 |
| JAN | Jackson International Airport (Jackson, MS) | 16093 | 26098 | 72435 |
| JAX | Jacksonville International Airport (Jacksonville, FL) | 41529 | 47338 | 123156 |
| JFK | John F. Kennedy International Airport (New York, NY) | 226607 | 118700 | 360511 |
| LAN | Capital City Airport (Lansing, MI) | 6851 | 32302 | 82390 |
| LAS | McCarran International Airport (Las Vegas, NV) | 274934 | 76603 | 463403 |
| LAX | Los Angeles International Airport (Los Angeles, CA) | 497792 | 237928 | 763748 |
| LBB | Lubbock International Airport (Lubbock, TX) | 21794 | 17993 | 72139 |
| LEX | Blue Grass Airport (Lexington, KY) | 12807 | 22757 | 79244 |
| LGA | La Guardia Airport (New York, NY) | 241063 | 81369 | 342618 |
| LGB | Long Beach Airport Daugherty Field (Long Beach, CA) | 8143 | 4837 | 264434 |

## APPENDIX B: 175 ASQP AIRPORTS – 1996 OPERATIONS, Cont.

| Code | Description | AC Ops | AT Ops | Total Ops |
|---|---|---|---|---|
| LIT | Adams Field Airport (Little Rock, AR) | 34354 | 25019 | 145946 |
| LNK | Lincoln Muni Airport (Lincoln, NE) | 6734 | 11173 | 71562 |
| LSE | La Crosse Muni Airport (LA Crosse, WI) | 2208 | 9352 | 28837 |
| MAF | Midland International Airport (Midland/Odessa, TX) | 15241 | 10278 | 51120 |
| MBS | MBS-International Airport (Saginaw, MI) | 7874 | 12734 | 40036 |
| MCI | Kansas City International Airport (Kansas City, MO) | 125388 | 55691 | 196058 |
| MCO | Orlando International Airport (Orlando, FL) | 194726 | 112651 | 341942 |
| MDT | Harrisburg International Airport (Harrisburg, PA) | 20621 | 26493 | 68747 |
| MDW | Chicago Midway Airport (Chicago, IL) | 126057 | 48431 | 253808 |
| MEM | Memphis International Airport (Memphis, TN) | 193321 | 103514 | 363444 |
| MFE | McAllen Miller International Airport (McAllen, TX) | 7840 | 5526 | 49287 |
| MFR | Rogue Valley International-Medford Airport (Medford, OR) | 1813 | 15861 | 45442 |
| MGM | Montgomery Regional (Dannelly Field) Airport (Montgomery, AL) | 5936 | 7980 | 58258 |
| MHT | Manchester Airport (Manchester, NH) | 14367 | 29755 | 75861 |
| MIA | Miami International Airport (Miami, FL) | 314540 | 161235 | 546487 |
| MKE | General Mitchell International Airport (Milwaukee, WI) | 86383 | 59180 | 192604 |
| MLB | Melbourne International Airport (Melbourne, FL) | 6461 | 5118 | 81601 |
| MLI | Quad City International Airport (Moline, IL) | 12056 | 14116 | 54462 |
| MLU | Monroe Regional Airport (Monroe, LA) | 4866 | 12006 | 47120 |
| MOB | Mobile Regional Airport (Mobile, AL) | 9508 | 9553 | 59612 |
| MOT | Minot International Airport (Minot, ND) | 1804 | 6224 | 19398 |
| MRY | Monterey Peninsula Airport (Monterey, CA) | 1723 | 28580 | 81778 |
| MSN | Dane County Regional-Truax Field Airport (Madison, WI) | 15405 | 15595 | 92186 |
| MSO | Missoula International Airport (Missoula, MT) | 3408 | 12685 | 35842 |
| MSP | Minneapolis-St. Paul International Airport (Minneapolis/St. Paul, MN) | 303732 | 121922 | 480513 |
| MSY | New Orleans International Airport (New Orleans, LA) | 100839 | 37415 | 163210 |
| MYR | Myrtle Beach International Airport (Myrtle Beach, SC) | 12810 | 12894 | 45493 |
| OAK | Metropolitan Oakland International Airport (Oakland, CA) | 169641 | 64734 | 401305 |
| OKC | Will Rogers World Airport (Oklahoma City, OK) | 40406 | 8827 | 149410 |
| OMA | Eppley Airfield Airport (Omaha, NE) | 49526 | 30136 | 129739 |
| ONT | Ontario International Airport (Ontario, CA) | 94040 | 31623 | 149257 |
| ORD | Chicago-O'Hare International Airport (Chicago, IL) | 751067 | 119735 | 909186 |
| ORF | Norfolk International Airport (Norfolk, VA) | 37590 | 20941 | 132074 |
| PBI | Palm Beach International Airport (West Palm Beach, FL) | 56703 | 31587 | 183691 |
| PDX | Portland International Airport (Portland, OR) | 119872 | 127312 | 300622 |
| PHL | Philadelphia International Airport (Philadelphia, PA) | 217420 | 136779 | 406121 |
| PHX | Phoenix Sky Harbor International Airport (Phoenix, AZ) | 353981 | 87085 | 537544 |
| PIT | Pittsburgh International Airport (Pittsburgh, PA) | 258339 | 152420 | 447436 |
| PNS | Pensacola Regional Airport (Pensacola, FL) | 14427 | 27774 | 93452 |
| PSC | Tri-Cities Airport (Pasco, WA) | 2904 | 17425 | 44536 |
| PSP | Palm Springs Regional Airport (Palm Springs, CA) | 8886 | 30686 | 80676 |
| PVD | Theodore Francis Green State Airport (Providence, RI) | 27700 | 31805 | 106489 |
| PWM | Portland International Jetport Airport (Portland, ME) | 14809 | 33446 | 80882 |
| RAP | Rapid City Regional Airport (Rapid City, SD) | 2073 | 11361 | 36709 |
| RDU | Raleigh-Durham International Airport (Raleigh-Durham, NC) | 92936 | 54265 | 223080 |
| RIC | Richmond International Airport (Richmond, VA) | 39199 | 25431 | 127746 |
| RNO | Reno Cannon International Airport (Reno, NV) | 78657 | 18812 | 146554 |
| ROA | Roanoke Regional/Woodrum Field Airport (Roanoke, VA) | 8561 | 27508 | 65643 |

| | | | | |
|---|---|---|---|---|
| ROC | Greater Rochester International Airport (Rochester, NY) | 38183 | 45577 | 126075 |

## APPENDIX B: 175 ASQP AIRPORTS – 1996 OPERATIONS, Cont.

| Code | Description | AC Ops | AT Ops | Total Ops |
|---|---|---|---|---|
| RST | Rochester International Airport (Rochester, MN) | 8512 | 2889 | 35122 |
| RSW | Southwest Florida International Airport (Fort Myers, FL) | 38131 | 20777 | 69659 |
| SAN | San Diego International-Lindbergh Field Airport (San Diego, CA) | 155012 | 63803 | 243595 |
| SAT | San Antonio International Airport (San Antonio, TX) | 86784 | 39746 | 246449 |
| SAV | Savannah International Airport (Savannah, GA) | 13975 | 5738 | 64041 |
| SBA | Santa Barbara Municipal Airport (Santa Barbara, CA) | 4520 | 44844 | 120955 |
| SBN | Michiana Regional Transportation Center Airport (South Bend, IN) | 16830 | 18047 | 61334 |
| SDF | Louisville International-Standiford Field Airport (Louisville, KY) | 100250 | 34460 | 172541 |
| SEA | Seattle-Tacoma International Airport (Seattle, WA) | 238421 | 151262 | 397497 |
| SFO | San Francisco International Airport (San Francisco, CA) | 322328 | 77387 | 428815 |
| SGF | Springfield-Branson Regional Airport (Springfield, MO) | 10034 | 18488 | 72490 |
| SHV | Shreveport Regional Airport (Shreveport, LA) | 14426 | 25963 | 72471 |
| SJC | San Jose International Airport (San Jose, CA) | 115785 | 9125 | 210844 |
| SLC | Salt Lake City International Airport (Salt Lake City, UT) | 196258 | 90889 | 373467 |
| SMF | Sacramento International Airport (Sacramento, CA) | 79925 | 38239 | 145839 |
| SNA | John Wayne Airport-Orange County Airport (Santa Ana, CA) | 80989 | 20404 | 369535 |
| SRQ | Sarasota/Bradenton International Airport (Sarasota/Bradenton, FL) | 17439 | 17027 | 125467 |
| STL | Lambert-St. Louis International Airport (St. Louis, MO) | 360760 | 116432 | 517352 |
| SUX | Sioux Gateway Airport (Sioux City, IA) | 1217 | 14999 | 43312 |
| SWF | Stewart International Airport (Newburgh, NY) | 15636 | 11044 | 73057 |
| SYR | Syracuse Hancock International Airport (Syracuse, NY) | 29088 | 60171 | 126400 |
| TLH | Tallahassee Regional Airport (Tallahassee, FL) | 8395 | 40878 | 92120 |
| TOL | Toledo Express Airport (Toledo, OH) | 23241 | 17717 | 76169 |
| TPA | Tampa International Airport (Tampa, FL) | 115910 | 109335 | 272782 |
| TRI | Tri-Cities Regional TN/VA Airport (Bristol/Johnson/Kingsport, TN) | 6982 | 13342 | 54649 |
| TUL | Tulsa International Airport (Tulsa, OK) | 53774 | 15295 | 171324 |
| TUS | Tucson International Airport (Tucson, AZ) | 46449 | 14330 | 181030 |
| TVC | Cherry Capital Airport (Traverse City, MI) | 2968 | 17738 | 63609 |
| TYS | McGhee Tyson Airport (Knoxville, TN) | 22190 | 23951 | 108115 |
| VPS | Eglin AFB Airport (Valparaiso, FL) | 4434 | 11300 | 115734 |

# APPENDIX C: SUMMARY OF DELAY COSTS FOR 175 AIRPORTS

| Airport | ADOC (Delays in Min) | | ADOC Costs | PVT (Delayed PAX Min) | | PVT Costs | Total Costs |
|---|---|---|---|---|---|---|---|
| | AC | AT | (Dollars) | AC | AT | (Dollars) | (Dollars) |
| ABE | 28,539 | 27,925 | 1,255,688 | 92,249 | 90,266 | 1,410,425 | 2,666,113 |
| ABQ | 122,939 | 49,776 | 4,583,997 | 441,062 | 178,580 | 9,483,754 | 14,067,751 |
| AGS | 6,559 | 14,477 | 382,912 | 21,455 | 47,354 | 598,409 | 981,321 |
| ALB | 43,968 | 117,753 | 2,809,046 | 127,230 | 340,743 | 3,267,480 | 6,076,526 |
| AMA | 11,837 | 9,319 | 494,315 | 49,165 | 38,708 | 1,292,572 | 1,786,887 |
| ATL | 1,619,665 | 422,281 | 57,659,456 | 3,313,077 | 863,789 | 84,996,494 | 142,655,949 |
| AUS | 102,319 | 27,069 | 3,647,115 | 350,180 | 92,640 | 6,799,182 | 10,446,296 |
| AVL | 6,585 | 12,211 | 357,226 | 24,666 | 45,737 | 710,250 | 1,067,477 |
| AVP | 11,325 | 24,473 | 654,996 | 39,520 | 85,401 | 974,369 | 1,629,366 |
| AZO | 9,282 | 29,641 | 648,992 | 29,114 | 92,970 | 822,428 | 1,471,420 |
| BDL | 106,889 | 107,268 | 4,734,346 | 299,537 | 300,599 | 7,177,423 | 11,911,769 |
| BFL | 3,329 | 79,561 | 1,039,381 | 7,662 | 183,133 | 545,909 | 1,585,291 |
| BGM | 3,529 | 26,838 | 428,921 | 12,911 | 98,186 | 468,907 | 897,828 |
| BGR | 2,856 | 10,622 | 217,257 | 37,678 | 140,139 | 913,166 | 1,130,424 |
| BHM | 46,883 | 26,866 | 1,840,380 | 187,720 | 107,572 | 3,304,984 | 5,145,364 |
| BIL | 21,323 | 72,479 | 1,542,202 | 65,375 | 222,214 | 1,058,382 | 2,600,584 |
| BIS | 8,186 | 33,262 | 655,686 | 21,116 | 85,799 | 433,588 | 1,089,274 |
| BNA | 136,521 | 101,609 | 5,632,618 | 451,269 | 335,869 | 10,117,055 | 15,749,673 |
| BOI | 48,942 | 39,528 | 2,055,557 | 207,086 | 167,252 | 4,032,266 | 6,087,822 |
| BOS | 577,988 | 508,813 | 24,766,883 | 1,348,355 | 1,186,980 | 36,441,260 | 61,208,143 |
| BTR | 13,701 | 30,418 | 801,905 | 40,525 | 89,968 | 1,023,930 | 1,825,836 |
| BTV | 12,738 | 75,260 | 1,295,312 | 40,922 | 241,775 | 1,501,680 | 2,796,992 |
| BUF | 71,388 | 75,639 | 3,208,714 | 240,578 | 254,905 | 4,641,302 | 7,850,016 |
| BUR | 45,691 | 28,422 | 1,819,776 | 240,438 | 149,561 | 5,379,006 | 7,198,782 |
| BWI | 219,435 | 127,982 | 8,639,980 | 729,306 | 425,356 | 17,591,155 | 26,231,134 |
| BZN | 9,658 | 12,588 | 461,648 | 32,842 | 42,807 | 345,469 | 807,118 |
| CAE | 29,285 | 24,684 | 1,242,044 | 121,454 | 102,373 | 1,830,596 | 3,072,640 |
| CAK | 6,920 | 10,379 | 346,706 | 33,916 | 50,866 | 534,544 | 881,250 |
| CHA | 2,720 | 4,995 | 146,984 | 10,372 | 19,047 | 224,679 | 371,663 |
| CHS | 36,709 | 7,263 | 1,279,818 | 137,591 | 27,223 | 2,467,541 | 3,747,359 |
| CID | 21,518 | 27,424 | 1,021,307 | 79,777 | 101,671 | 1,279,253 | 2,300,560 |
| CLE | 316,589 | 244,634 | 13,167,272 | 693,128 | 535,593 | 16,856,010 | 30,023,282 |
| CLT | 432,112 | 200,808 | 16,414,513 | 1,121,755 | 521,294 | 23,831,184 | 40,245,697 |
| CMH | 167,852 | 131,659 | 7,004,045 | 476,481 | 373,741 | 10,081,691 | 17,085,736 |
| COS | 115,183 | 20,961 | 3,994,345 | 330,140 | 60,080 | 7,169,356 | 11,163,700 |
| CRP | 9,169 | 10,378 | 419,897 | 52,030 | 58,890 | 1,085,749 | 1,505,646 |
| CRW | 6,491 | 26,931 | 526,413 | 26,107 | 108,320 | 636,897 | 1,163,310 |
| CVG | 457,974 | 470,528 | 20,412,590 | 908,675 | 933,584 | 23,655,742 | 44,068,332 |
| DAB | 15,342 | 5,471 | 563,376 | 46,022 | 16,410 | 1,050,177 | 1,613,553 |
| DAL | 61,051 | 16,247 | 2,177,248 | 360,546 | 95,952 | 7,331,785 | 9,509,032 |
| DAY | 132,273 | 51,218 | 4,904,648 | 364,558 | 141,163 | 3,533,138 | 8,437,786 |
| DCA | 335,714 | 152,452 | 12,711,031 | 835,717 | 379,511 | 19,390,853 | 32,101,884 |
| DEN | 444,662 | 152,080 | 16,252,774 | 1,386,164 | 474,085 | 36,508,955 | 52,761,729 |
| DFW | 1,423,752 | 531,150 | 52,556,750 | 2,774,002 | 1,034,878 | 64,582,124 | 117,138,874 |

## APPENDIX C: SUMMARY OF DELAY COSTS FOR 175 AIRPORTS, Cont.

| Airport | ADOC | | ADOC Costs | PVT (Delayed PAX Min) | | PVT Costs (Dollars) | Total Costs (Dollars) |
|---|---|---|---|---|---|---|---|
| | AC | AT | | AC | AT | | |
| DLH | 6,184 | 11,645 | 337,558 | 18,053 | 33,993 | 334,377 | 671,936 |
| DRO | 1,313 | 23,445 | 317,085 | 4,181 | 74,654 | 205,780 | 522,865 |
| DSM | 51,890 | 42,484 | 2,186,086 | 180,834 | 148,054 | 2,451,811 | 4,637,897 |
| DTW | 652,613 | 187,349 | 23,434,029 | 1,430,816 | 410,751 | 31,513,600 | 54,947,629 |
| EGE | 4,081 | 2,315 | 159,927 | 13,681 | 7,761 | 371,242 | 531,169 |
| ELM | 2,102 | 10,518 | 191,499 | 9,921 | 49,643 | 251,264 | 442,764 |
| ELP | 77,109 | 14,770 | 2,682,634 | 279,297 | 53,497 | 4,555,621 | 7,238,255 |
| ERI | 3,123 | 8,705 | 203,529 | 14,296 | 39,848 | 395,418 | 598,947 |
| EUG | 8,804 | 32,629 | 668,387 | 40,894 | 151,560 | 1,582,202 | 2,250,589 |
| EWR | 1,091,885 | 389,250 | 40,094,398 | 2,194,403 | 782,291 | 48,816,487 | 88,910,885 |
| FAR | 10,485 | 19,935 | 574,545 | 32,005 | 60,852 | 650,377 | 1,224,922 |
| FAT | 32,134 | 163,364 | 2,957,609 | 109,797 | 558,193 | 3,557,105 | 6,514,713 |
| FAY | 4,974 | 7,596 | 250,804 | 18,359 | 28,035 | 408,800 | 659,604 |
| FCA | 3,329 | 15,264 | 286,963 | 14,098 | 64,643 | 1,369,334 | 1,656,297 |
| FLL | 201,874 | 122,963 | 8,009,627 | 634,696 | 386,598 | 15,629,614 | 23,639,241 |
| FSD | 20,233 | 32,922 | 1,043,817 | 60,234 | 98,011 | 956,043 | 1,999,860 |
| FWA | 17,057 | 30,022 | 906,507 | 62,086 | 109,274 | 1,077,051 | 1,983,558 |
| GEG | 58,292 | 53,672 | 2,525,403 | 228,008 | 209,935 | 4,678,131 | 7,203,534 |
| GFK | 6,609 | 14,364 | 383,213 | 16,852 | 36,626 | 249,251 | 632,465 |
| GNV | 4,005 | 18,787 | 350,210 | 14,921 | 69,992 | 612,300 | 962,510 |
| GRB | 18,142 | 18,639 | 808,620 | 54,048 | 55,528 | 866,248 | 1,674,868 |
| GRR | 38,466 | 60,122 | 1,955,569 | 135,429 | 211,673 | 2,443,460 | 4,399,029 |
| GSO | 110,828 | 65,903 | 4,378,505 | 282,256 | 167,842 | 3,976,940 | 8,355,446 |
| GSP | 32,326 | 26,778 | 1,365,522 | 99,419 | 82,357 | 2,009,609 | 3,375,131 |
| GTF | 12,586 | 26,571 | 720,612 | 40,737 | 86,002 | 399,265 | 1,119,877 |
| GUC | 1,953 | 11,936 | 203,255 | 5,480 | 33,491 | 2,125,859 | 2,329,114 |
| HDN | 5,067 | 12,622 | 312,639 | 17,037 | 42,437 | 718,476 | 1,031,115 |
| HLN | 1,669 | 12,424 | 199,700 | 11,795 | 87,833 | 241,708 | 441,408 |
| HOU | 121,229 | 19,828 | 4,177,850 | 482,299 | 78,882 | 9,011,366 | 13,189,216 |
| HPN | 23,432 | 73,781 | 1,626,060 | 54,324 | 171,057 | 1,340,287 | 2,966,347 |
| HRL | 7,484 | 4,728 | 298,923 | 49,103 | 31,020 | 1,146,811 | 1,445,734 |
| HSV | 23,405 | 16,711 | 957,356 | 72,630 | 51,858 | 1,145,266 | 2,102,623 |
| HVN | 669 | 9,171 | 129,096 | 3,934 | 53,924 | 337,655 | 466,751 |
| IAD | 155,018 | 303,325 | 8,595,169 | 459,525 | 899,157 | 14,001,129 | 22,596,298 |
| IAH | 563,604 | 145,575 | 20,048,064 | 1,149,590 | 296,931 | 23,808,069 | 43,856,133 |
| ICT | 51,812 | 28,797 | 2,023,413 | 165,947 | 92,234 | 2,105,388 | 4,128,801 |
| IDA | 2,267 | 10,851 | 200,768 | 11,633 | 55,686 | 400,876 | 601,644 |
| ILM | 6,707 | 22,167 | 477,702 | 24,087 | 79,612 | 636,040 | 1,113,742 |
| IND | 228,038 | 150,266 | 9,180,746 | 643,334 | 423,926 | 10,028,065 | 19,208,811 |
| ISP | 13,882 | 31,092 | 815,672 | 54,679 | 122,467 | 1,744,249 | 2,559,922 |
| ITH | 2,801 | 17,000 | 290,100 | 9,505 | 57,696 | 340,353 | 630,453 |
| JAC | 6,587 | 17,122 | 414,758 | 23,171 | 60,231 | 627,684 | 1,042,441 |
| JAN | 35,116 | 56,947 | 1,809,373 | 102,290 | 165,884 | 1,885,817 | 3,695,190 |
| JAX | 78,970 | 90,017 | 3,623,762 | 249,219 | 284,079 | 5,256,893 | 8,880,655 |
| JFK | 688,140 | 360,458 | 26,616,129 | 1,570,712 | 822,761 | 28,458,204 | 55,074,333 |

## APPENDIX C: SUMMARY OF DELAY COSTS FOR 175 AIRPORTS, Cont.

| Airport | ADOC (Delays in Min) | | ADOC Costs (Dollars) | PVT (Delayed PAX Min) | | PVT Costs (Dollars) | Total Costs (Dollars) |
|---|---|---|---|---|---|---|---|
| | AC | AT | | AC | AT | | |
| LAN | 9,150 | 43,141 | 802,648 | 37,560 | 177,091 | 1,124,480 | 1,927,128 |
| LAS | 442,019 | 123,157 | 15,828,314 | 1,449,098 | 403,752 | 41,124,393 | 56,952,708 |
| LAX | 1,102,875 | 527,138 | 42,065,687 | 3,141,070 | 1,501,327 | 78,608,830 | 120,674,517 |
| LBB | 10,151 | 8,381 | 428,486 | 76,047 | 62,784 | 1,337,501 | 1,765,987 |
| LEX | 23,082 | 41,014 | 1,231,223 | 68,052 | 120,922 | 1,499,091 | 2,730,313 |
| LGA | 529,400 | 178,695 | 19,322,343 | 1,224,676 | 413,380 | 27,519,998 | 46,842,341 |
| LGB | 16,700 | 9,920 | 659,663 | 39,632 | 23,542 | 520,827 | 1,180,490 |
| LIT | 54,949 | 40,018 | 2,256,818 | 189,768 | 138,203 | 3,707,364 | 5,964,182 |
| LNK | 10,458 | 17,352 | 543,467 | 34,020 | 56,446 | 678,581 | 1,222,048 |
| LSE | 3,413 | 14,454 | 280,222 | 8,949 | 37,903 | 234,901 | 515,123 |
| MAF | 9,995 | 6,741 | 404,219 | 52,307 | 35,274 | 1,021,345 | 1,425,564 |
| MBS | 12,471 | 20,169 | 641,945 | 41,732 | 67,490 | 868,855 | 1,510,800 |
| MCI | 208,052 | 92,406 | 7,853,166 | 669,739 | 297,464 | 13,585,311 | 21,438,478 |
| MCO | 401,991 | 232,556 | 15,805,662 | 1,099,106 | 635,844 | 33,395,169 | 49,200,832 |
| MDT | 32,162 | 41,320 | 1,530,364 | 108,581 | 139,501 | 2,152,027 | 3,682,391 |
| MDW | 154,817 | 59,480 | 5,735,113 | 560,202 | 215,229 | 10,491,232 | 16,226,345 |
| MEM | 312,195 | 167,165 | 12,117,717 | 677,741 | 362,898 | 8,895,277 | 21,012,994 |
| MFE | 9,800 | 6,908 | 399,820 | 31,450 | 22,167 | 656,907 | 1,056,728 |
| MFR | 2,688 | 23,513 | 362,627 | 15,308 | 133,922 | 809,521 | 1,172,148 |
| MGM | 7,454 | 10,021 | 359,899 | 27,463 | 36,919 | 483,347 | 843,246 |
| MHT | 24,678 | 51,109 | 1,401,312 | 77,693 | 160,908 | 1,552,122 | 2,953,434 |
| MIA | 792,387 | 406,182 | 30,544,304 | 1,754,838 | 899,540 | 29,982,318 | 60,526,621 |
| MKE | 153,257 | 104,995 | 6,216,976 | 461,196 | 315,960 | 7,879,234 | 14,096,210 |
| MLB | 8,326 | 6,596 | 348,191 | 32,465 | 25,717 | 817,645 | 1,165,836 |
| MLI | 18,034 | 21,116 | 834,098 | 56,538 | 66,199 | 773,152 | 1,607,250 |
| MLU | 6,542 | 16,142 | 401,837 | 24,530 | 60,523 | 389,061 | 790,898 |
| MOB | 15,015 | 15,086 | 665,242 | 52,454 | 52,703 | 839,186 | 1,504,428 |
| MOT | 3,187 | 10,997 | 232,428 | 8,691 | 29,986 | 209,659 | 442,088 |
| MRY | 1,945 | 32,270 | 440,953 | 12,742 | 211,352 | 1,084,423 | 1,525,376 |
| MSN | 21,765 | 22,033 | 966,249 | 77,618 | 78,575 | 1,610,552 | 2,576,800 |
| MSO | 5,218 | 19,421 | 397,102 | 20,400 | 75,930 | 521,353 | 918,455 |
| MSP | 645,294 | 259,029 | 24,034,610 | 1,311,606 | 526,496 | 30,974,951 | 55,009,561 |
| MSY | 157,491 | 58,435 | 5,809,924 | 510,175 | 189,294 | 10,716,483 | 16,526,407 |
| MYR | 16,166 | 16,272 | 716,594 | 78,162 | 78,675 | 1,715,455 | 2,432,049 |
| OAK | 201,592 | 76,926 | 7,461,726 | 729,380 | 278,327 | 11,682,497 | 19,144,223 |
| OKC | 51,950 | 11,349 | 1,823,717 | 204,601 | 44,697 | 4,527,716 | 6,351,433 |
| OMA | 87,862 | 53,463 | 3,485,434 | 294,448 | 179,168 | 5,061,121 | 8,546,555 |
| ONT | 107,652 | 36,200 | 3,927,532 | 452,155 | 152,047 | 8,205,801 | 12,133,333 |
| ORD | 1,786,599 | 284,819 | 61,484,328 | 3,891,396 | 620,366 | 84,621,090 | 146,105,418 |
| ORF | 63,600 | 35,431 | 2,484,709 | 192,468 | 107,222 | 3,765,667 | 6,250,375 |
| PBI | 129,829 | 72,323 | 5,072,077 | 379,172 | 211,222 | 10,421,932 | 15,494,008 |
| PDX | 242,203 | 257,236 | 10,893,586 | 737,192 | 782,946 | 21,437,866 | 32,331,452 |
| PHL | 420,660 | 264,637 | 16,788,698 | 1,125,818 | 708,252 | 24,535,684 | 41,324,382 |
| PHX | 624,161 | 153,554 | 22,112,479 | 1,788,200 | 439,926 | 40,374,657 | 62,487,136 |

## APPENDIX C: SUMMARY OF DELAY COSTS FOR 175 AIRPORTS, Cont.

| Airport | ADOC (Delays in Min) | | ADOC Costs | PVT (Delayed PAX Min) | | PVT Costs | Total Costs |
|---|---|---|---|---|---|---|---|
| | AC | AT | (Dollars) | AC | AT | (Dollars) | (Dollars) |
| PIT | 440,415 | 259,845 | 17,375,624 | 1,138,369 | 671,637 | 23,271,671 | 40,647,295 |
| PNS | 19,793 | 38,105 | 1,090,160 | 67,394 | 129,743 | 1,524,628 | 2,614,788 |
| PSC | 4,404 | 26,425 | 452,578 | 17,972 | 107,839 | 740,291 | 1,192,869 |
| PSP | 17,786 | 61,420 | 1,297,654 | 58,484 | 201,964 | 2,058,326 | 3,355,980 |
| PVD | 46,687 | 53,606 | 2,146,910 | 133,270 | 153,020 | 3,213,381 | 5,360,291 |
| PWM | 31,456 | 71,043 | 1,855,198 | 96,104 | 217,049 | 2,635,540 | 4,490,739 |
| RAP | 5,830 | 31,948 | 563,607 | 10,475 | 57,408 | 554,315 | 1,117,922 |
| RDU | 174,032 | 101,617 | 6,853,639 | 528,644 | 308,673 | 10,849,480 | 17,703,119 |
| RIC | 79,795 | 51,768 | 3,203,000 | 216,548 | 140,489 | 3,338,467 | 6,541,467 |
| RNO | 101,774 | 24,341 | 3,597,447 | 377,589 | 90,306 | 8,784,651 | 12,382,098 |
| ROA | 11,700 | 37,594 | 820,745 | 35,404 | 113,761 | 818,904 | 1,639,649 |
| ROC | 58,042 | 69,281 | 2,699,913 | 196,896 | 235,024 | 3,554,358 | 6,254,271 |
| RST | 15,997 | 5,429 | 584,201 | 40,314 | 13,683 | 478,523 | 1,062,723 |
| RSW | 83,353 | 45,418 | 3,244,516 | 235,108 | 128,107 | 6,828,288 | 10,072,804 |
| SAN | 220,868 | 90,909 | 8,252,774 | 816,941 | 336,253 | 21,962,611 | 30,215,385 |
| SAT | 114,322 | 52,358 | 4,333,733 | 413,160 | 189,222 | 8,408,514 | 12,742,247 |
| SAV | 19,336 | 7,939 | 722,267 | 78,860 | 32,379 | 1,711,342 | 2,433,609 |
| SBA | 5,352 | 53,097 | 795,536 | 31,937 | 316,858 | 1,281,011 | 2,076,548 |
| SBN | 21,610 | 23,172 | 974,529 | 65,084 | 69,791 | 1,005,443 | 1,979,972 |
| SDF | 182,982 | 62,898 | 6,691,867 | 552,142 | 189,794 | 5,431,814 | 12,123,681 |
| SEA | 547,232 | 347,182 | 21,874,421 | 1,567,125 | 994,235 | 42,789,987 | 64,664,407 |
| SFO | 855,962 | 205,506 | 30,265,247 | 2,357,846 | 566,090 | 62,551,676 | 92,816,923 |
| SGF | 13,921 | 25,650 | 753,268 | 48,397 | 89,173 | 1,005,211 | 1,758,480 |
| SHV | 23,855 | 42,933 | 1,278,845 | 61,621 | 110,902 | 867,685 | 2,146,530 |
| SJC | 192,929 | 15,205 | 6,457,493 | 578,593 | 45,599 | 13,054,637 | 19,512,130 |
| SLC | 454,406 | 210,440 | 17,252,898 | 1,139,426 | 527,679 | 30,187,992 | 47,440,890 |
| SMF | 116,115 | 55,554 | 4,429,473 | 400,249 | 191,493 | 9,956,991 | 14,386,464 |
| SNA | 139,241 | 35,080 | 4,942,626 | 383,019 | 96,496 | 9,847,535 | 14,790,162 |
| SRQ | 31,700 | 30,951 | 1,393,985 | 99,504 | 97,153 | 2,620,478 | 4,014,463 |
| STL | 827,918 | 267,203 | 30,074,440 | 2,010,627 | 648,911 | 42,676,623 | 72,751,064 |
| SUX | 2,254 | 27,780 | 398,444 | 5,830 | 71,852 | 294,963 | 693,407 |
| SWF | 25,760 | 18,195 | 1,051,361 | 76,035 | 53,705 | 1,195,284 | 2,246,645 |
| SYR | 44,296 | 91,630 | 2,514,034 | 143,083 | 295,979 | 2,761,031 | 5,275,065 |
| TLH | 11,465 | 55,829 | 1,026,501 | 41,320 | 201,201 | 1,303,906 | 2,330,407 |
| TOL | 39,557 | 30,155 | 1,640,409 | 119,250 | 90,906 | 871,792 | 2,512,201 |
| TPA | 255,454 | 240,964 | 11,134,464 | 723,057 | 682,041 | 19,553,231 | 30,687,695 |
| TRI | 6,615 | 12,640 | 363,216 | 22,743 | 43,461 | 452,735 | 815,951 |
| TUL | 73,870 | 21,011 | 2,650,242 | 289,319 | 82,291 | 5,379,275 | 8,029,517 |
| TUS | 81,201 | 25,051 | 2,936,145 | 273,677 | 84,432 | 5,535,821 | 8,471,966 |
| TVC | 4,282 | 25,589 | 438,809 | 15,242 | 91,095 | 486,848 | 925,657 |
| TYS | 29,868 | 32,238 | 1,349,412 | 106,264 | 114,697 | 1,897,034 | 3,246,446 |
| VPS | 5,141 | 13,101 | 320,620 | 14,210 | 36,213 | 352,106 | 672,726 |

## APPENDIX C: SUMMARY OF DELAY COSTS FOR 175 AIRPORTS, Cont.

| Airport | ADOC (Delays in Min) | | ADOC Costs (Dollars) | PVT (Delayed PAX Min) | | PVT Costs (Dollars) | Total Costs (Dollars) |
|---|---|---|---|---|---|---|---|
| | AC | AT | | AC | AT | | |
| TOTAL | $ Millions | | 1,014.8 | | | 1,558.6 | 2,573.5 |
| | | | | | | | |
| Extrapolate to NAS | $ Millions | | 1086.4 | | | 1702.8 | 2,789.2 |
| | | | | | | | |
| Extrapolate to NAS | Including GA | $ Millions | 1137.6 | | | 1822.0 | 2,959.5 |

## APPENDIX D: RECOMMENDED WEATHER DELAY BASELINE (ITWS COST BENEFIT FACTORS)

| Airport | ADOC (Delays in Min) | | ADOC Costs | PVT (Delayed PAX Min) | | PVT Costs | Total Costs |
|---|---|---|---|---|---|---|---|
| | AC | AT | (Dollars) | AC | AT | (Dollars) | (Dollars) |
| ABE | 8,671 | 8,484 | 381,506 | 42,407 | 41,495 | 648,369 | 1,029,876 |
| ABQ | 36,585 | 14,813 | 1,364,128 | 191,618 | 77,583 | 4,120,180 | 5,484,309 |
| AGS | 1,951 | 4,306 | 113,883 | 10,007 | 22,085 | 279,091 | 392,974 |
| ALB | 13,529 | 36,234 | 864,367 | 57,087 | 152,888 | 1,466,088 | 2,330,455 |
| AMA | 3,636 | 2,862 | 151,830 | 20,906 | 16,459 | 549,630 | 701,460 |
| ATL | 520,323 | 135,659 | 18,523,309 | 1,421,715 | 370,671 | 36,473,878 | 54,997,187 |
| AUS | 31,077 | 8,222 | 1,107,733 | 153,056 | 40,491 | 2,971,762 | 4,079,495 |
| AVL | 1,865 | 3,458 | 101,173 | 8,804 | 16,324 | 253,498 | 354,670 |
| AVP | 3,389 | 7,323 | 196,005 | 16,973 | 36,679 | 418,478 | 614,484 |
| AZO | 2,877 | 9,188 | 201,162 | 14,669 | 46,843 | 414,379 | 615,541 |
| BDL | 33,140 | 33,257 | 1,467,838 | 130,508 | 130,970 | 3,127,186 | 4,595,024 |
| BFL | 1,137 | 27,171 | 354,964 | 4,484 | 107,159 | 319,435 | 674,399 |
| BGM | 1,073 | 8,158 | 130,386 | 5,589 | 42,504 | 202,986 | 333,372 |
| BGR | 798 | 2,969 | 60,718 | 28,215 | 104,943 | 683,821 | 744,539 |
| BHM | 13,961 | 8,001 | 548,048 | 81,934 | 46,952 | 1,442,524 | 1,990,572 |
| BIL | 6,495 | 22,078 | 469,776 | 29,570 | 100,509 | 478,716 | 948,491 |
| BIS | 2,620 | 10,646 | 209,872 | 9,827 | 39,929 | 201,781 | 411,652 |
| BNA | 42,436 | 31,584 | 1,750,821 | 204,647 | 152,314 | 4,588,002 | 6,338,823 |
| BOI | 14,430 | 11,655 | 606,077 | 93,327 | 75,375 | 1,817,214 | 2,423,291 |
| BOS | 210,751 | 185,528 | 9,030,722 | 671,302 | 590,959 | 18,142,910 | 27,173,632 |
| BTR | 4,161 | 9,238 | 243,550 | 17,732 | 39,366 | 448,025 | 691,574 |
| BTV | 3,914 | 23,124 | 397,998 | 17,836 | 105,377 | 654,504 | 1,052,502 |
| BUF | 22,323 | 23,652 | 1,003,368 | 113,926 | 120,710 | 2,197,896 | 3,201,264 |
| BUR | 13,077 | 8,135 | 520,847 | 104,270 | 64,859 | 2,332,690 | 2,853,537 |
| BWI | 67,549 | 39,397 | 2,659,665 | 315,051 | 183,749 | 7,599,161 | 10,258,826 |
| BZN | 2,913 | 3,797 | 139,240 | 16,531 | 21,547 | 173,890 | 313,130 |
| CAE | 8,517 | 7,179 | 361,204 | 52,332 | 44,110 | 788,757 | 1,149,961 |
| CAK | 1,939 | 2,909 | 97,161 | 14,427 | 21,638 | 227,387 | 324,548 |
| CHA | 803 | 1,475 | 43,415 | 4,042 | 7,422 | 87,548 | 130,963 |
| CHS | 10,847 | 2,146 | 378,182 | 58,530 | 11,581 | 1,049,672 | 1,427,854 |
| CID | 6,551 | 8,349 | 310,949 | 36,542 | 46,571 | 585,970 | 896,919 |
| CLE | 100,140 | 77,380 | 4,164,909 | 295,381 | 228,246 | 7,183,290 | 11,348,199 |
| CLT | 132,519 | 61,583 | 5,033,970 | 441,904 | 205,359 | 9,388,065 | 14,422,035 |
| CMH | 51,446 | 40,353 | 2,146,709 | 217,002 | 170,211 | 4,591,460 | 6,738,168 |
| COS | 35,133 | 6,394 | 1,218,358 | 143,741 | 26,158 | 3,121,507 | 4,339,865 |
| CRP | 2,649 | 2,998 | 121,302 | 22,910 | 25,931 | 478,081 | 599,383 |
| CRW | 1,960 | 8,131 | 158,937 | 11,036 | 45,787 | 269,219 | 428,157 |
| CVG | 141,817 | 145,705 | 6,321,008 | 358,452 | 368,278 | 9,331,673 | 15,652,681 |
| DAB | 4,583 | 1,634 | 168,297 | 19,512 | 6,957 | 445,245 | 613,542 |
| DAL | 17,959 | 4,779 | 640,462 | 148,824 | 39,606 | 3,026,371 | 3,666,833 |
| DAY | 41,282 | 15,985 | 1,530,721 | 166,795 | 64,586 | 1,616,511 | 3,147,231 |
| DCA | 106,908 | 48,548 | 4,047,830 | 354,691 | 161,070 | 8,229,772 | 12,277,602 |

## APPENDIX D: RECOMMENDED WEATHER DELAY BASELINE (ITWS COST BENEFIT FACTORS), Cont.

| Airport | ADOC (Delays in Min) | | ADOC Costs | PVT (Delayed PAX Min) | | PVT Costs | Total Costs |
|---|---|---|---|---|---|---|---|
| | AC | AT | (Dollars) | AC | AT | (Dollars) | (Dollars) |
| DEN | 135,177 | 46,232 | 4,940,843 | 579,113 | 198,064 | 15,252,756 | 20,193,599 |
| DFW | 460,081 | 171,639 | 16,983,537 | 1,189,359 | 443,706 | 27,689,711 | 44,673,248 |
| DLH | 2,040 | 3,840 | 111,325 | 9,584 | 18,046 | 177,516 | 288,842 |
| DRO | 386 | 6,901 | 93,333 | 1,809 | 32,299 | 89,030 | 182,363 |
| DSM | 16,155 | 13,227 | 680,621 | 82,922 | 67,891 | 1,124,289 | 1,804,910 |
| DTW | 205,375 | 58,958 | 7,374,607 | 612,544 | 175,846 | 13,491,228 | 20,865,835 |
| EGE | 1,412 | 801 | 55,323 | 7,902 | 4,483 | 214,420 | 269,743 |
| ELM | 613 | 3,065 | 55,810 | 4,070 | 20,365 | 103,078 | 158,887 |
| ELP | 22,597 | 4,328 | 786,148 | 116,919 | 22,395 | 1,907,069 | 2,693,218 |
| ERI | 922 | 2,571 | 60,109 | 6,014 | 16,762 | 166,333 | 226,442 |
| EUG | 2,591 | 9,604 | 196,733 | 20,217 | 74,927 | 782,192 | 978,925 |
| EWR | 408,372 | 145,582 | 14,995,551 | 1,164,812 | 415,248 | 25,912,285 | 40,907,836 |
| FAR | 3,437 | 6,534 | 188,330 | 17,185 | 32,674 | 349,214 | 537,544 |
| FAT | 9,872 | 50,187 | 908,608 | 51,947 | 264,090 | 1,682,922 | 2,591,531 |
| FAY | 1,473 | 2,250 | 74,290 | 7,218 | 11,023 | 160,731 | 235,021 |
| FCA | 1,025 | 4,701 | 88,385 | 6,709 | 30,763 | 651,653 | 740,038 |
| FLL | 66,081 | 40,250 | 2,621,842 | 299,513 | 182,435 | 7,375,601 | 9,997,443 |
| FSD | 6,382 | 10,385 | 329,256 | 28,299 | 46,047 | 449,165 | 778,421 |
| FWA | 4,983 | 8,771 | 264,829 | 29,682 | 52,241 | 514,909 | 779,737 |
| GEG | 17,322 | 15,949 | 750,446 | 103,426 | 95,228 | 2,122,037 | 2,872,483 |
| GFK | 2,279 | 4,953 | 132,133 | 8,732 | 18,979 | 129,161 | 261,294 |
| GNV | 1,198 | 5,619 | 104,751 | 7,182 | 33,689 | 294,711 | 399,462 |
| GRB | 6,015 | 6,180 | 268,086 | 29,127 | 29,925 | 466,833 | 734,919 |
| GRR | 12,036 | 18,811 | 611,871 | 65,440 | 102,281 | 1,180,695 | 1,792,566 |
| GSO | 34,275 | 20,382 | 1,354,126 | 121,369 | 72,171 | 1,710,072 | 3,064,199 |
| GSP | 10,043 | 8,319 | 424,222 | 44,976 | 37,258 | 909,129 | 1,333,351 |
| GTF | 3,772 | 7,962 | 215,934 | 18,384 | 38,811 | 180,183 | 396,117 |
| GUC | 608 | 3,716 | 63,272 | 2,509 | 15,335 | 973,369 | 1,036,641 |
| HDN | 1,695 | 4,223 | 104,592 | 9,507 | 23,680 | 400,910 | 505,501 |
| HLN | 463 | 3,447 | 55,401 | 5,919 | 44,073 | 121,286 | 176,687 |
| HOU | 37,304 | 6,101 | 1,285,575 | 212,533 | 34,761 | 3,971,008 | 5,256,583 |
| HPN | 7,783 | 24,508 | 540,127 | 25,366 | 79,872 | 625,825 | 1,165,952 |
| HRL | 2,231 | 1,409 | 89,114 | 22,004 | 13,901 | 513,915 | 603,029 |
| HSV | 7,133 | 5,093 | 291,758 | 32,227 | 23,010 | 508,172 | 799,930 |
| HVN | 195 | 2,677 | 37,683 | 1,935 | 26,523 | 166,078 | 203,760 |
| IAD | 49,313 | 96,491 | 2,734,216 | 206,715 | 404,481 | 6,298,325 | 9,032,541 |
| IAH | 177,191 | 45,767 | 6,302,912 | 463,396 | 119,692 | 9,596,954 | 15,899,866 |
| ICT | 15,727 | 8,741 | 614,196 | 76,017 | 42,251 | 964,442 | 1,578,638 |
| IDA | 639 | 3,058 | 56,570 | 5,013 | 23,996 | 172,743 | 229,313 |
| ILM | 1,955 | 6,462 | 139,247 | 9,755 | 32,241 | 257,584 | 396,831 |
| IND | 70,016 | 46,137 | 2,818,834 | 286,169 | 188,571 | 4,460,701 | 7,279,535 |
| ISP | 4,284 | 9,596 | 251,731 | 26,406 | 59,143 | 842,355 | 1,094,086 |
| ITH | 842 | 5,108 | 87,163 | 4,212 | 25,569 | 150,833 | 237,997 |
| JAC | 1,997 | 5,192 | 125,756 | 10,799 | 28,071 | 292,532 | 418,288 |

## APPENDIX D: RECOMMENDED WEATHER DELAY BASELINE (ITWS COST BENEFIT FACTORS), Cont.

| Airport | ADOC (Delays in Min) | | ADOC Costs | PVT (Delayed PAX Min) | | PVT Costs | Total Costs |
|---|---|---|---|---|---|---|---|
| | AC | AT | (Dollars) | AC | AT | (Dollars) | (Dollars) |
| JAN | 10,461 | 16,964 | 539,003 | 44,396 | 71,996 | 818,473 | 1,357,476 |
| JAX | 24,814 | 28,285 | 1,138,640 | 114,360 | 130,356 | 2,412,243 | 3,550,883 |
| JFK | 241,444 | 126,472 | 9,338,662 | 780,136 | 408,646 | 14,134,531 | 23,473,193 |
| LAN | 2,788 | 13,147 | 244,599 | 19,504 | 91,962 | 583,931 | 828,531 |
| LAS | 132,967 | 37,048 | 4,761,436 | 638,388 | 177,870 | 18,117,017 | 22,878,453 |
| LAX | 369,288 | 176,507 | 14,085,308 | 1,578,292 | 754,371 | 39,498,547 | 53,583,855 |
| LBB | 3,075 | 2,538 | 129,777 | 33,409 | 27,582 | 587,587 | 717,364 |
| LEX | 6,878 | 12,221 | 366,862 | 29,295 | 52,055 | 645,340 | 1,012,202 |
| LGA | 183,753 | 62,024 | 6,706,721 | 560,212 | 189,095 | 12,588,664 | 19,295,384 |
| LGB | 4,690 | 2,786 | 185,265 | 14,649 | 8,702 | 192,510 | 377,775 |
| LIT | 16,643 | 12,120 | 683,536 | 84,302 | 61,395 | 1,646,952 | 2,330,488 |
| LNK | 3,212 | 5,329 | 166,894 | 15,246 | 25,295 | 304,097 | 470,992 |
| LSE | 1,170 | 4,957 | 96,101 | 4,736 | 20,059 | 124,316 | 220,416 |
| MAF | 2,965 | 1,999 | 119,892 | 22,294 | 15,034 | 435,317 | 555,209 |
| MBS | 3,825 | 6,186 | 196,897 | 19,477 | 31,499 | 405,506 | 602,402 |
| MCI | 63,640 | 28,266 | 2,402,165 | 298,760 | 132,694 | 6,060,198 | 8,462,364 |
| MCO | 131,529 | 76,091 | 5,171,517 | 512,621 | 296,556 | 15,575,430 | 20,746,946 |
| MDT | 9,833 | 12,634 | 467,905 | 50,258 | 64,569 | 996,084 | 1,463,989 |
| MDW | 47,565 | 18,274 | 1,762,011 | 252,955 | 97,185 | 4,737,243 | 6,499,254 |
| MEM | 94,993 | 50,864 | 3,687,119 | 278,551 | 149,151 | 3,655,954 | 7,343,073 |
| MFE | 2,964 | 2,089 | 120,913 | 14,066 | 9,914 | 293,794 | 414,707 |
| MFR | 782 | 6,841 | 105,509 | 8,481 | 74,194 | 448,482 | 553,991 |
| MGM | 2,108 | 2,835 | 101,798 | 11,793 | 15,854 | 207,566 | 309,364 |
| MHT | 7,542 | 15,619 | 428,244 | 33,265 | 68,894 | 664,551 | 1,092,795 |
| MIA | 265,746 | 136,223 | 10,243,779 | 797,489 | 408,797 | 13,625,503 | 23,869,282 |
| MKE | 46,807 | 32,067 | 1,898,772 | 203,751 | 139,587 | 3,480,949 | 5,379,720 |
| MLB | 2,482 | 1,966 | 103,813 | 14,841 | 11,756 | 373,774 | 477,587 |
| MLI | 5,389 | 6,309 | 249,225 | 27,484 | 32,180 | 375,840 | 625,065 |
| MLU | 1,915 | 4,726 | 117,637 | 10,456 | 25,799 | 165,842 | 283,479 |
| MOB | 4,347 | 4,368 | 192,616 | 22,306 | 22,411 | 356,855 | 549,472 |
| MOT | 1,043 | 3,598 | 76,058 | 4,469 | 15,418 | 107,801 | 183,859 |
| MRY | 546 | 9,062 | 123,831 | 6,435 | 106,747 | 547,706 | 671,536 |
| MSN | 6,872 | 6,957 | 305,078 | 41,077 | 41,583 | 852,327 | 1,157,406 |
| MSO | 1,497 | 5,571 | 113,904 | 10,267 | 38,214 | 262,382 | 376,287 |
| MSP | 201,002 | 80,685 | 7,486,515 | 553,917 | 222,350 | 13,081,331 | 20,567,846 |
| MSY | 49,660 | 18,426 | 1,831,974 | 234,344 | 86,950 | 4,922,505 | 6,754,479 |
| MYR | 4,674 | 4,705 | 207,199 | 33,737 | 33,958 | 740,436 | 947,635 |
| OAK | 58,556 | 22,345 | 2,167,412 | 309,975 | 118,285 | 4,964,881 | 7,132,292 |
| OKC | 15,616 | 3,411 | 548,192 | 93,221 | 20,365 | 2,062,930 | 2,611,123 |
| OMA | 26,502 | 16,126 | 1,051,328 | 136,036 | 82,776 | 2,338,260 | 3,389,588 |
| ONT | 31,924 | 10,735 | 1,164,712 | 202,875 | 68,221 | 3,681,820 | 4,846,533 |
| ORD | 627,784 | 100,081 | 21,604,661 | 1,889,434 | 301,213 | 41,087,054 | 62,691,715 |
| ORF | 20,150 | 11,225 | 787,212 | 86,576 | 48,231 | 1,693,886 | 2,481,098 |
| PBI | 42,437 | 23,640 | 1,657,915 | 183,858 | 102,420 | 5,053,519 | 6,711,434 |

## APPENDIX D: RECOMMENDED WEATHER DELAY BASELINE (ITWS COST BENEFIT FACTORS), Cont.

| Airport | ADOC (Delays in Min) | | ADOC Costs | PVT (Delayed PAX Min) | | PVT Costs | Total Costs |
|---|---|---|---|---|---|---|---|
| | AC | AT | (Dollars) | AC | AT | (Dollars) | (Dollars) |
| PDX | 72,259 | 76,744 | 3,250,017 | 332,961 | 353,626 | 9,682,650 | 12,932,667 |
| PHL | 137,219 | 86,324 | 5,476,453 | 501,889 | 315,739 | 10,938,003 | 16,414,456 |
| PHX | 187,419 | 46,108 | 6,639,805 | 751,121 | 184,788 | 16,959,098 | 23,598,903 |
| PIT | 134,694 | 79,469 | 5,314,056 | 455,967 | 269,020 | 9,321,325 | 14,635,381 |
| PNS | 5,728 | 11,027 | 315,484 | 28,311 | 54,502 | 640,461 | 955,945 |
| PSC | 1,287 | 7,722 | 132,243 | 8,231 | 49,387 | 339,033 | 471,276 |
| PSP | 5,418 | 18,711 | 395,322 | 28,800 | 99,456 | 1,013,608 | 1,408,930 |
| PVD | 14,614 | 16,779 | 672,002 | 58,792 | 67,505 | 1,417,586 | 2,089,588 |
| PWM | 9,490 | 21,433 | 559,692 | 44,716 | 100,992 | 1,226,300 | 1,785,992 |
| RAP | 1,806 | 9,898 | 174,613 | 4,317 | 23,659 | 228,445 | 403,058 |
| RDU | 54,265 | 31,685 | 2,137,044 | 235,264 | 137,370 | 4,828,379 | 6,965,424 |
| RIC | 24,678 | 16,010 | 990,570 | 95,043 | 61,660 | 1,465,246 | 2,455,816 |
| RNO | 29,916 | 7,155 | 1,057,457 | 161,582 | 38,645 | 3,759,223 | 4,816,680 |
| ROA | 3,448 | 11,080 | 241,900 | 13,520 | 43,441 | 312,712 | 554,612 |
| ROC | 17,983 | 21,466 | 836,527 | 89,847 | 107,246 | 1,621,920 | 2,458,447 |
| RST | 4,969 | 1,686 | 181,453 | 18,832 | 6,392 | 223,535 | 404,988 |
| RSW | 26,956 | 14,688 | 1,049,255 | 109,883 | 59,873 | 3,191,354 | 4,240,609 |
| SAN | 67,797 | 27,905 | 2,533,262 | 379,649 | 156,264 | 10,206,473 | 12,739,735 |
| SAT | 34,623 | 15,857 | 1,312,471 | 184,088 | 84,310 | 3,746,496 | 5,058,968 |
| SAV | 5,690 | 2,336 | 212,525 | 35,078 | 14,403 | 761,230 | 973,755 |
| SBA | 1,529 | 15,169 | 227,269 | 17,146 | 170,110 | 687,732 | 915,001 |
| SBN | 6,560 | 7,035 | 295,848 | 28,635 | 30,706 | 442,368 | 738,216 |
| SDF | 55,199 | 18,974 | 2,018,677 | 248,092 | 85,279 | 2,440,656 | 4,459,334 |
| SEA | 167,740 | 106,420 | 6,705,036 | 716,985 | 454,879 | 19,577,112 | 26,282,149 |
| SFO | 328,763 | 78,932 | 11,624,443 | 1,423,133 | 341,677 | 37,754,513 | 49,378,956 |
| SGF | 4,275 | 7,877 | 231,324 | 21,874 | 40,304 | 454,333 | 685,657 |
| SHV | 7,577 | 13,637 | 406,198 | 28,788 | 51,811 | 405,364 | 811,562 |
| SJC | 58,898 | 4,642 | 1,971,379 | 258,619 | 20,382 | 5,835,156 | 7,806,535 |
| SLC | 136,584 | 63,254 | 5,185,835 | 472,990 | 219,046 | 12,531,424 | 17,717,259 |
| SMF | 34,836 | 16,667 | 1,328,890 | 180,066 | 86,150 | 4,479,493 | 5,808,383 |
| SNA | 41,432 | 10,438 | 1,470,718 | 156,628 | 39,460 | 4,026,943 | 5,497,660 |
| SRQ | 9,817 | 9,585 | 431,688 | 45,720 | 44,639 | 1,204,038 | 1,635,727 |
| STL | 267,223 | 86,244 | 9,706,968 | 946,238 | 305,390 | 20,084,401 | 29,791,369 |
| SUX | 766 | 9,442 | 135,421 | 3,078 | 37,938 | 155,740 | 291,161 |
| SWF | 7,727 | 5,458 | 315,363 | 32,985 | 23,298 | 518,533 | 833,896 |
| SYR | 13,519 | 27,965 | 767,278 | 63,571 | 131,502 | 1,226,715 | 1,993,993 |
| TLH | 3,412 | 16,612 | 305,435 | 19,677 | 95,816 | 620,945 | 926,380 |
| TOL | 11,611 | 8,851 | 481,512 | 53,947 | 41,125 | 394,390 | 875,903 |
| TPA | 82,984 | 78,277 | 3,617,008 | 335,020 | 316,016 | 9,059,776 | 12,676,784 |
| TRI | 1,937 | 3,702 | 106,379 | 8,600 | 16,433 | 171,187 | 277,566 |
| TUL | 22,112 | 6,289 | 793,317 | 130,878 | 37,226 | 2,433,407 | 3,226,725 |
| TUS | 24,002 | 7,405 | 867,892 | 119,895 | 36,989 | 2,425,177 | 3,293,069 |
| TVC | 1,317 | 7,871 | 134,971 | 7,323 | 43,767 | 233,907 | 368,878 |
| TYS | 8,971 | 9,683 | 405,307 | 48,323 | 52,158 | 862,671 | 1,267,978 |
| VPS | 1,511 | 3,850 | 94,222 | 6,349 | 16,180 | 157,321 | 251,543 |

## APPENDIX D: RECOMMENDED WEATHER DELAY BASELINE (ITWS COST BENEFIT FACTORS), Cont.

| Airport | ADOC (Delays in Min) | | ADOC Costs (Dollars) | PVT (Delayed PAX Min) | | PVT Costs (Dollars) | Total Costs (Dollars) |
|---|---|---|---|---|---|---|---|
| | AC | AT | | AC | AT | | |
| TOTAL WX | $ Millions | | 327.7 | | | 712.8 | 1,040.5 |
| | | | | | | | |
| Extrapolate to NAS | AC & AT Only | $ Millions | 350.8 | | | 778.8 | 1,129.5 |
| | | | | | | | |
| Extrapolate to NAS | Including GA | $ Millions | 367.3 | | | 833.2 | 1,200.5 |

# APPENDIX E: DELAYS PER AIRPORT

| ID's | AIRPORT | G-G Delay | Arrival Delay |
|---|---|---|---|
| ABE | Lehigh Valley International Airport (Allentown, PA) | 3.28 | 12.16 |
| ABQ | Albuquerque International Airport (Albuquerque, NM) | 2.91 | 11.76 |
| AGS | Bush Field Airport (Augusta,GA) | 2.87 | 10.8 |
| ALB | Albany County Airport (Albany, NY) | 3.93 | 12.82 |
| AMA | Amarillo International Airport (Amarillo, TX) | 2.04 | 9.58 |
| ATL | Atlanta International Airport (Atlanta, GA) | 5.55 | 13.6 |
| AUS | Austin Robert Mueller Municipal Airport (Austin, TX) | 2.61 | 10.15 |
| AVL | Asheville Regional Airport (Asheville, NC) | 2.07 | 8.93 |
| AVP | Wilkes-Barre/Scranton International Airport (Wilkes-Barre/Scranton, PA) | 3.12 | 12.31 |
| AZO | Kalamazoo/Battle Creek International Airport (Kalamazoo, MI) | 3.04 | 10.62 |
| BDL | Bradley International Airport (Windsor Locks, CT) | 3.86 | 13.07 |
| BFL | Meadows Field Airport (Bakersfield, CA) | 6.7 | 19.22 |
| BGM | Binghamton Regional/Edwin A Link Field Airport (Binghamton, NY) | 2.63 | 10.69 |
| BGR | Bangor International Airport (Bangor, ME) | 0.88 | 15.51 |
| BHM | Birmingham International Airport (Birmingham, AL) | 2.35 | 10.89 |
| BIL | Billings Logan International Airport (Billings, MT) | 4.71 | 15.49 |
| BIS | Bismarck Muni Airport (Bismarck, ND) | 4.66 | 14.67 |
| BNA | Nashville International Airport (Nashville, TN) | 3.06 | 10.81 |
| BOI | Boise Air Terminal/Gowen Field Airport (Boise, ID) | 2.56 | 11.62 |
| BOS | General Edward Lawrence Logan International Airport (Boston, MA) | 5.26 | 15.34 |
| BTR | Baton Rouge Metopolitan, Ryan Field Airport (Baton Rouge, LA) | 2.89 | 10.96 |
| BTV | Burlington International Airport (Burlington, VT) | 3.17 | 11.94 |
| BUF | Greater Buffalo International Airport (Buffalo, NY) | 3.35 | 13.46 |
| BUR | Burbank-Glendale-Pasadena Airport (Burbank, CA) | 1.54 | 9.15 |
| BWI | Baltimore/Washington International Airport (Baltimore,MD) | 2.97 | 11.7 |
| BZN | Gallatin Field Airport (Bozeman, MT) | 3.92 | 16.1 |
| CAE | Columbia Metropolitan Airport (Columbia, SC) | 2.42 | 12.14 |
| CAK | Akron-Canton Regional Airport (Akron, OH) | 1.46 | 7.53 |
| CID | The Eastern Iowa Airport (Cedar Rapids, IA) | 2.47 | 10.77 |
| CLE | Cleveland-Hopkins International Airport (Cleveland, OH) | 4.47 | 11.66 |
| CLT | Charlotte/Douglas International Airport (Charlotte, NC) | 3.26 | 9.7 |
| CMH | Port Columbus International Airport (Columbus, OH) | 4.29 | 14.49 |
| COS | City of Colorado Springs Muni Airport (Colorado Springs, CO) | 4.07 | 13.49 |
| CRP | Corpus Christi International Airport (Corpus Christi, TX) | 1.06 | 6.56 |
| CRW | Yeager Airport (Charleston, WV) | 2.27 | 10.36 |
| CVG | Cincinnati/Northern Kentucky International Airport (Covington/Cincinnati, OH, KY) | 4.97 | 11.65 |
| DAB | Daytona Beach Regional Airport (Dytona Beach, FL) | 3.74 | 12.1 |
| DAL | Dallas Love Field Airport (Dallas, TX) | 1.23 | 7.95 |
| DAY | James M Cox Dayton International Airport (Dayton, OH) | 3.93 | 12.05 |
| DCA | Washington National Airport (Washington, DC) | 3.9 | 11.1 |
| DEN | Denver International Airport (Denver, CO) | 2.81 | 10.85 |
| DFW | Dallas/Fort Worth International Airport (Dallas-Fort Worth, TX) | 4.79 | 11.68 |

## APPENDIX E: DELAYS PER AIRPORT, Cont.

| ID's | AIRPORT | G-G Delay | Arrival Delay |
|---|---|---|---|
| DLH | Duluth International Airport (Duluth, MN) | 3.22 | 10.14 |
| DRO | Durango-La Plata County Airport (Durango, CO) | 3.43 | 13.74 |
| DSM | Des Moines International Airport (Des Moines, IA) | 3.11 | 12.69 |
| DTW | Detroit Metropolitan Wayne County Airport (Detroit, MI) | 3.81 | 10.7 |
| EGE | Eagle County Regional Airport (Vail/Eagle, CO) | 3.81 | 13.78 |
| ELM | Elmira/Corning Regional Airport (Elmira, NY) | 1.76 | 8.39 |
| ELP | El Paso International Airport (El Paso, TX) | 2.54 | 10.32 |
| ERI | Erie International Airport (Erie, PA) | 2.19 | 10.64 |
| EUG | Mahlon Sweet Field Airport (Eugene, OR) | 2.81 | 16.13 |
| EWR | Newark International Airport (Newark, NJ) | 7.35 | 19.75 |
| FAR | Hector International Airport (Fargo, ND) | 3.59 | 12.86 |
| FAT | Fresno Yosemite International Airport (Fresno, CA) | 4.59 | 18.8 |
| FAY | Fayetteville Regional/Grannis Field Airport (Fayetteville, NC) | 2.11 | 8.36 |
| FCA | Glacier Park Intenational Airport (Kalispell, MT) | 6.7 | 20.64 |
| FLL | Fort Lauderdale/Hollywood International Airport (Fort Lauderdale, FL) | 4.1 | 15.02 |
| FSD | Joe Foss Field Airport (Sioux Falls, SD) | 3.78 | 12.79 |
| FWA | Fort Wayne International Airport (Fort Wayne, IN) | 2.72 | 11 |
| GEG | Spokane International Airport (Spokane, WA) | 2.66 | 12.38 |
| GFK | Grand Forks International Airport (Grand Forks, ND) | 3.81 | 11.89 |
| GNV | Gainesville Regional Airport (Gainesville, FL) | 2.54 | 10.46 |
| GRB | Austin Straubel International Airport (Green Bay, WI) | 3.65 | 12.78 |
| GRR | Kent County International Airport (Grand Rapids, MI) | 3.3 | 13.31 |
| GSO | Piedmont Triad International Airport (Greensboro, NC) | 3.91 | 11.92 |
| GSP | Greenville-Spartanburg International Airport (Greer, SC) | 3.21 | 11.08 |
| GTF | Great Falls International Airport (Great Falls, MT) | 3.42 | 13.92 |
| GUC | Gunnison County Airport (Gunnison, CO) | 4.14 | 12.91 |
| HDN | Yampa Valley Airport (Hayden, CO also Steamboat Springs & Craig.) | 3.9 | 17.37 |
| HLN | Helena Regional Airport (Helena, MT) | 2.54 | 18.19 |
| HOU | William P. Hobby Airport (Houston, TX) | 2.07 | 9.25 |
| HPN | Westchester County Airport (White Plaines, NY) | 4.34 | 11.75 |
| HRL | Rio Grande Valley International Airport (Harlingen, TX) | 1.21 | 9.17 |
| HSV | Huntsville International-Carl Jones Field Airport (Huntsville, AL) | 3.37 | 11.76 |
| HVN | Tweed-New Haven Airport (New Haven, CT) | 1.49 | 10.61 |
| IAD | Washington Dulles International Airport (Washington, DC) | 3.51 | 12.51 |
| IAH | George Bush Intercontinental Airport (Houston, TX) | 3.96 | 9.78 |
| ICT | Wichita Mid-Continent Airport (Wichita, KS) | 3.29 | 12.13 |
| IDA | Fanning Field Airport (Idaho Falls, ID) | 2.2 | 12.15 |
| ILM | New Hanover International Airport (Wilmington, NC) | 2.92 | 11.29 |
| IND | Indianapolis International Airport (Indianapolis, IN) | 4.3 | 13.98 |
| ISP | Long Island MacAuthur Airport (Islip, NY) | 2.6 | 11.79 |
| ITH | Tompkins County Airport (Ithaca, NY) | 2.46 | 8.57 |
| JAC | Jackson Hole Airport (Jackson, WY) | 3.59 | 14.21 |
| JAN | Jackson International Airport (Jackson, MS) | 4.26 | 13.51 |
| JAX | Jacksonville International Airport (Jacksonville, FL) | 3.89 | 14.25 |
| JFK | John F. Kennedy International Airport (New York, NY) | 6.14 | 18.62 |
| LAN | Capital City Airport (Lansing, MI) | 2.75 | 12.61 |
| LAS | McCarran International Airport (Las Vegas, NV) | 3.27 | 12.64 |

## APPENDIX E: DELAYS PER AIRPORT, Cont.

| ID's | AIRPORT | G-G Delay | Arrival Delay |
|---|---|---|---|
| LAX | Los Angeles International Airport (Los Angeles, CA) | 4.5 | 15.23 |
| LBB | Lubbock International Airport (Lubbock, TX) | 0.93 | 7.39 |
| LEX | Blue Grass Airport (Lexington, KY) | 3.6 | 12.54 |
| LGA | La Guardia Airport (New York, NY) | 4.58 | 12.81 |
| LGB | Long Beach Airport Daugherty Field (Long Beach, CA) | 4.11 | 10.04 |
| LIT | Adams Field Airport (Little Rock, AR) | 3.27 | 12.91 |
| LNK | Lincoln Muni Airport (Lincoln, NE) | 3.09 | 12.34 |
| LSE | La Crosse Muni Airport (LA Crosse, WI) | 3.2 | 9.95 |
| MAF | Midland International Airport (Midland/Odessa, TX) | 1.32 | 7.63 |
| MBS | MBS-International Airport (Saginaw, MI) | 3.21 | 12.44 |
| MCI | Kansas City International Airport (Kansas City, MO) | 3.4 | 12.57 |
| MCO | Orlando International Airport (Orlando, FL) | 4.19 | 14.13 |
| MDT | Harrisburg International Airport (Harrisburg, PA) | 3.28 | 13.07 |
| MDW | Chicago Midway Airport (Chicago, IL) | 2.51 | 10.97 |
| MEM | Memphis International Airport (Memphis, TN) | 3.3 | 8.72 |
| MFE | McAllen Miller International Airport (McAllen, TX) | 2.58 | 9.11 |
| MFR | Rogue Valley International-Medford Airport (Medford, OR) | 3.01 | 23.48 |
| MGM | Montgomery Regional (Dannelly Field) Airport (Montgomery, AL) | 2.51 | 10.42 |
| MHT | Manchester Airport (Manchester, NH) | 3.56 | 12.98 |
| MIA | Miami International Airport (Miami, FL) | 5.15 | 14.7 |
| MKE | General Mitchell International Airport (Milwaukee, WI) | 3.65 | 12.43 |
| MLB | Melbourne International Airport (Melbourne, FL) | 2.64 | 11.76 |
| MLI | Quad City International Airport (Moline, IL) | 2.97 | 10.14 |
| MLU | Monroe Regional Airport (Monroe, LA) | 2.41 | 12.43 |
| MOB | Mobile Regional Airport (Mobile, AL) | 3.13 | 12.56 |
| MOT | Minot International Airport (Minot, ND) | 3.99 | 11.94 |
| MRY | Monterey Peninsula Airport (Monterey, CA) | 2.26 | 18.43 |
| MSN | Dane County Regional-Truax Field Airport (Madison, WI) | 3.05 | 13.1 |
| MSO | Missoula International Airport (Missoula, MT) | 3.01 | 14.74 |
| MSP | Minneapolis-St. Paul International Airport (Minneapolis/St. Paul, MN) | 4.28 | 11.11 |
| MSY | New Orleans International Airport (New Orleans, LA) | 3.2 | 11.89 |
| MYR | Myrtle Beach International Airport (Myrtle Beach, SC) | 2.61 | 12.55 |
| OAK | Metropolitan Oakland International Airport (Oakland, CA) | 2.39 | 9.71 |
| OKC | Will Rogers World Airport (Oklahoma City, OK) | 2.56 | 11.75 |
| OMA | Eppley Airfield Airport (Omaha, NE) | 3.64 | 13.49 |
| ONT | Ontario International Airport (Ontario, CA) | 2.35 | 11.35 |
| ORD | Chicago-O'Hare International Airport (Chicago, IL) | 5.02 | 14.27 |
| ORF | Norfolk International Airport (Norfolk, VA) | 3.5 | 12.71 |
| PBI | Palm Beach International Airport (West Palm Beach, FL) | 4.54 | 16.22 |
| PDX | Portland International Airport (Portland, OR) | 4.06 | 14.86 |
| PHL | Philadelphia International Airport (Philadelphia, PA) | 3.91 | 12.51 |
| PHX | Phoenix Sky Harbor International Airport (Phoenix, AZ) | 3.59 | 11.99 |
| PIT | Pittsburgh International Airport (Pittsburgh, PA) | 3.44 | 10.41 |
| PNS | Pensacola Regional Airport (Pensacola, FL) | 2.71 | 10.01 |
| PSC | Tri-Cities Airport (Pasco, WA) | 3.53 | 13.39 |
| PSP | Palm Springs Regional Airport (Palm Springs, CA) | 4.12 | 17.22 |
| PVD | Theodore Francis Green State Airport (Providence, RI) | 3.48 | 12.01 |

# APPENDIX E: DELAYS PER AIRPORT, Cont.

| ID's | AIRPORT | G-G Delay | Arrival Delay |
|---|---|---|---|
| PWM | Portland International Jetport Airport (Portland, ME) | 3.99 | 13.72 |
| RAP | Rapid City Regional Airport (Rapid City, SD) | 5.83 | 11.33 |
| RDU | Raleigh-Durham International Airport (Raleigh-Durham, NC) | 3.72 | 13.31 |
| RIC | Richmond International Airport (Richmond, VA) | 4.12 | 12.74 |
| RNO | Reno Cannon International Airport (Reno, NV) | 2.64 | 12.03 |
| ROA | Roanoke Regional/Woodrum Field Airport (Roanoke, VA) | 2.72 | 9.32 |
| ROC | Greater Rochester International Airport (Rochester, NY) | 3.11 | 12.86 |
| RST | Rochester International Airport (Rochester, MN) | 3.92 | 11.23 |
| RSW | Southwest Florida International Airport (Fort Myers, FL) | 4.45 | 15.14 |
| SAN | San Diego International-Lindbergh Field Airport (San Diego, CA) | 2.9 | 12.72 |
| SAT | San Antonio International Airport (San Antonio, TX) | 2.67 | 11.26 |
| SAV | Savannah International Airport (Savannah, GA) | 2.84 | 13.09 |
| SBA | Santa Barbara Municipal Airport (Santa Barbara, CA) | 2.34 | 17.18 |
| SBN | Michiana Regional Transportation Center Airport (South Bend, IN) | 2.6 | 9.23 |
| SDF | Louisville International-Standiford Field Airport (Louisville, KY) | 3.71 | 13.1 |
| SEA | Seattle-Tacoma International Airport (Seattle, WA) | 4.65 | 14.45 |
| SFO | San Francisco International Airport (San Francisco, CA) | 5.44 | 19.06 |
| SGF | Springfield-Branson Regional Airport (Springfield, MO) | 2.93 | 10.54 |
| SHV | Shreveport Regional Airport (Shreveport, LA) | 3.72 | 10.41 |
| SJC | San Jose International Airport (San Jose, CA) | 3.37 | 11.08 |
| SLC | Salt Lake City International Airport (Salt Lake City, UT) | 4.66 | 13.96 |
| SMF | Sacramento International  Airport (Sacramento, CA) | 2.97 | 11.86 |
| SNA | John Wayne Airport-Orange County Airport (Santa Ana, CA) | 3.45 | 10.61 |
| SRQ | Sarasota/Bradenton International Airport (Sarasota/Bradenton, FL) | 3.6 | 12.64 |
| STL | Lambert-St. Louis International Airport (St. Louis, MO) | 4.62 | 13.4 |
| SWF | Stewart International Airport (Newburgh, NY) | 3.4 | 12.43 |
| SYR | Syracuse Hancock International Airport (Syracuse, NY) | 3.1 | 11.92 |
| TLH | Tallahassee Regional Airport (Tallahassee, FL) | 2.74 | 10.73 |
| TOL | Toledo Express Airport (Toledo, OH) | 3.58 | 11.62 |
| TPA | Tampa International Airport (Tampa, FL) | 4.46 | 14.94 |
| TRI | Tri-Cities Regional TN/VA Airport (Bristol/Johnson/Kingsport, TN) | 1.9 | 7.26 |
| TUL | Tulsa International Airport (Tulsa, OK) | 2.81 | 12.83 |
| TUS | Tucson International Airport (Tucson, AZ) | 3.43 | 13.05 |
| TVC | Cherry Capital Airport (Traverse City, MI) | 3.08 | 11.99 |
| TYS | McGhee Tyson Airport (Knoxville, TN) | 2.75 | 11.1 |
| VPS | Eglin AFB Airport (Valparalso, FL) | 2.32 | 10.2 |

# APPENDIX F: DELAYS PER 30 BUSIEST AIRPORTS – 1996

| Rank (Ops) | Airport | G-G Delays | Arrival Delays |
|---|---|---|---|
| 1 | ORD | 5.0 | 14.3 |
| 2 | DFW | 4.8 | 11.7 |
| 3 | ATL | 5.6 | 13.6 |
| 4 | LAX | 4.5 | 15.2 |
| 5 | MIA | 5.2 | 14.7 |
| 6 | PHX | 3.6 | 12.0 |
| 7 | STL | 4.6 | 13.4 |
| 8 | LAS | 3.3 | 12.6 |
| 9 | DTW | 3.8 | 10.7 |
| 10 | OAK | 2.4 | 9.7 |
| 11 | SNA | 3.5 | 10.6 |
| 12 | DEN | 2.8 | 10.9 |
| 13 | LGB | 4.1 | 10.0 |
| 14 | BOS | 5.3 | 15.3 |
| 15 | MSP | 4.3 | 11.1 |
| 16 | CLT | 3.3 | 9.7 |
| 17 | SFO | 5.4 | 19.1 |
| 18 | PIT | 3.4 | 10.4 |
| 19 | EWR | 7.4 | 19.8 |
| 20 | PHL | 3.9 | 12.5 |
| 21 | SEA | 4.7 | 14.5 |
| 22 | IAH | 4.0 | 9.8 |
| 23 | CVG | 5.0 | 11.7 |
| 24 | MEM | 3.3 | 8.7 |
| 25 | MCO | 4.2 | 14.1 |
| 26 | LGA | 4.6 | 12.8 |
| 27 | JFK | 6.1 | 18.6 |
| 28 | DCA | 3.9 | 11.1 |
| 29 | IAD | 3.5 | 12.5 |
| 30 | PDX | 4.1 | 14.9 |
| Average Delays (Minutes) | | 4.3 | 12.9 |

## APPENDIX G: LIST OF ACRONYMS

| | |
|---|---|
| AC | Air Carrier |
| ADL | Aggregate Demand List |
| ADOC | Airline Direct Operating Costs |
| AIP | Airport Improvement Program |
| ARA | Associate Administrator for Research and Acquisition |
| ARTCC | Air Route Traffic Control Center |
| ASD-400 | Investment Analysis and Operations Research |
| ASQP | Airline Service Quality Performance |
| AT | Air Taxi |
| ATA | Air Transport Association |
| ATC | Air Traffic Control |
| ATL | Atlanta |
| AZ | arrival messages |
| | |
| C/AFT | CNS/ATM Focused Team |
| CDM | Collaborative Decision Making |
| CLT | Charlotte |
| CNS/ATM | Communications, Navigation and Surveillance/Air Traffic Management |
| CODAS | Consolidated Operations and Delay Analysis System |
| CTAS | Center-TRACON Automation System |
| | |
| DEN | Denver International Airport |
| DZ | departure messages |
| | |
| EDCT | Estimated Departure Clearance Time |
| ENP | enplanements |
| ETMS | Enhanced Traffic Management |
| EWR | Newark International Airport |
| | |
| FAA | Federal Aviation Administration |
| FAATC | FAA Technical Center |
| FFP-1 | Free Flight Phase 1 |
| | |
| GA | general aviation |
| GAO | General Accounting Office |
| | |
| IMC | Instrument Meteorological Conditions |
| ITWS | Integrated Terminal Weather System |
| | |
| JAG/AW | Joint Action Group for Aviation Weather |
| | |
| NAS | National Airspace System |

| | |
|---|---|
| NASPAC | National Airspace System Performance Analysis Capability |
| NCDC | National Climatic Data Center |
| OAG | Official Airline Guide |
| OPSNET | Operational Data Reporting Requirements Network |
| ORD | Chicago O'Hare International Airport |
| PMAC | Performance Monitoring Analysis Capability |
| PVT | Passenger Value of Time |
| TAF | Terminal Area Forecast |
| TD | Total Delay |
| TRACON | Terminal Radar Approach Control |